INTEGRATED MULTIMODAL INTERACTION FRAMEWORK FOR VIRTUAL REALITY FOOT REFLEXOLOGY STRESS THERAPY

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Abstrak

Kerangka dalam penyelidikan interaksi telah menyaksikan pelbagai komposisi daripada ramai penyelidik, dan telah digunakan untuk tujuan tertentu atau umum dalam beberapa domain. Kajian terdahulu telah menonjolkan realiti maya (VR) dalam terapi tekanan, dan mendedahkan terapi refleksologi kaki menggunakan teknologi VR. Walau bagaimanapun, kerangka interaksi untuk refleksologi kaki melalui realiti maya memerlukan kajian lanjut. Kajian ini membentangkan reka bentuk dan penilaian kerangka interaksi multimodal bersepadu untuk terapi tekanan refleksologi kaki realiti maya. Komponen kerangka yang dicadangkan telah dikenalpasti daripada sorotan karya dan kajian sebelumnya yang merangkumi prinsip reka bentuk, teknologi, komponen struktur, seni bina interaksi multimodal, dan komposisi segmen. Ini membentuk kerangka interaksi multimodal terintegrasi untuk terapi tekanan refleksologi kaki realiti maya. Kerangka yang dicadangkan kemudiannya telah disahkan melalui ulasan pakar. Ini diikuti dengan pembangunan prototaip yang meneroka keberkesanan aplikasi terapi refleksologi kaki realiti maya ke atas pengenduran dan pelepasan tekanan menggunakan Smith Relaxation States Inventory (SRSI-3). Eksperimen kuasi intervensi pra dan pasca ujian digunakan dalam kajian untuk tujuan penilaian. Penemuan ini mendedahkan bahawa Terapi Tekanan Refleksologi Kaki Realiti Maya (VR-FRST) secara berkesan membangkitkan kategori keadaan pengenduran yang melampau, kesungguhan, tenaga positif, dan pengenduran asas, dan juga mengurangkan keadaan tekanan pengguna. Kajian ini menyediakan kerangka interaksi multimodal yang bersepadu, teratur, praktikal dan disahkan untuk reka bentuk dan perkembangan terapi refleksologi kaki dalam persekitaran maya. Ini menyumbang kepada bidang reka bentuk interaksi bagi pembangun realiti maya dan terapi pelengkap untuk pengamal perubatan alternatif.

Kata kunci: Kerangka interaksi multimodal bersepadu, Terapi tekanan refleksologi kaki realiti maya, Smith Relaxation States Inventory, Pengenduran, Melepaskan tekanan.

Abstract

Frameworks in interaction research have seen varying compositions from numerous researchers, and have been applied for either a specific or general purposes in several domains. Previous studies have highlighted virtual reality (VR) in stress therapy, and revealed the potential of foot reflexology therapy using VR technology. However, the interaction framework for foot reflexology through virtual reality requires further investigation. This study presents the design and evaluation of an integrated multimodal interaction framework for virtual reality foot reflexology stress therapy. The components of the proposed framework were identified from the literature review and previous research, which included design principles, technology, structural components, multimodal interaction architecture, and segment composition. This formed the proposed integrated multimodal interaction framework for virtual reality foot reflexology stress therapy. The proposed framework was then validated using expert reviews. This was followed by prototype development, which explored the effectiveness of the virtual reality foot reflexology therapy application on relaxation and stress relief using Smith Relaxation States Inventory (SRSI-3). A pre and post-test intervention quasi experiment was employed in the study for the evaluation. The findings revealed that Virtual Reality Foot Reflexology Stress Therapy (VR–FRST) effectively evokes the relaxation state categories of transcendence, mindfulness, positive energy, and basic relaxation, and also reduces users stress state. This research provides a concise, organized, practical and validated integrated multimodal interaction framework for the design and development of foot reflexology therapy in a virtual environment. This contributes to the field of interaction design for virtual reality developers and complementary therapy for the alternative medical practitioners.

Keywords: Integrated multimodal interaction framework, Virtual reality foot reflexology stress therapy, Smith Relaxation States Inventory, Relaxation, Stress Relief.

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I Thank the Almighty God, the most high for his Mercy and Unmerited Grace upon my life for it has not been by my power, might nor my intelligence has he brought me this far, but only by His Grace and His alone have I done so. I say all Glory, Honour, Praise, and Adoration be ascribed unto Him alone.

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\- Okere Prince-Hector Chimeremeze (August 2019).

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List of Abbreviations

AI	Artificial Intelligence
AHP	Analytical Hierarchical Process
EPs	Exploratory Procedures
ET	Exposure Therapy
FR	Foot Reflexology
RA	Reflexology Artifact
SRSI-3	Smith Relaxation States Inventory 3
UUM	Universiti Utara Malaysia
VE	Virtual Environment
VR	Virtual Reality
VRET	Virtual Reality Exposure Therapy
VRST	Virtual Reality Stress Therapy
VR-FRST	Virtual Reality Foot Reflexology Stress Therapy
VR-Foot-ReST	Virtual Reality Foot Reflexology Stress Therapy Application

CHAPTER ONE
INTRODUCTION

1.1 Overview

This is the first introductory chapter of the thesis, which presents the research background, motivation, and purpose behind the execution of the research. The chapter also highlighted research objectives, problems and challenges the research aims to address. It also presents the research scope, limitations, as well as the research contributions.

1.2 Background of Research

Virtual reality is an immersive technology which blurs the boundaries between our physical environments and our virtual environments, enabling users' sense of immersive experience (Suh & Prophet, 2018). Research in several domains like education (Johnston et al., 2017; Solak & Erdem, 2015), entertainment (Liszio & Masuch, 2016), and healthcare (Khan et al., 2017; Wiederhold, Miller, & Wiederhold, 2018), underlines that VR technologies augments learning experiences (Ng & Lam, 2018), fosters participation in collaborative activity (Fu & Hwang, 2018), and increases creativity and engagement (Yang et al., 2018).

The advancement of VR technologies or applications have encouraged researchers on the utilization of VR technologies and applications to support, improve, or complement life, in the treatment of phobias (Maples-Keller, Yasinski, Manjin, & Rothbaum, 2017; Morina, Ijntema, Meyerbröker, & Emmelkamp, 2015a; Parsons, 2015; Peperkorn, Diemer, & Mühlberger, 2015; Zinzow et al., 2017), for relaxation and stress management (Jerdan, Grindle, Van Woerden, & Boulos, 2018; Pallavicini, Argenton, Toniazzi, Aceti, & Mantovani, 2016; Shah et al., 2015) and for complementary therapy tools and methods (Li, 2007; Menelas, Haidon, Ecrepont, & Girard, 2018; Patterson & Nanni, 2015; Scapin et al., 2018; Taneja, Vishal, Mahesh, & Geethanjali, 2017). Virtual Reality Stress Therapy (VRST) are technologies or applications that permits the utilization or exploration and interaction of virtual environments through sight, sound, touch and other sensory modalities in order to manage stress (Pallavicini et al., 2016; Shah et al., 2015).

World Health Organization declared stress as a global epidemic as it has been cited as the second most frequent health condition affecting people across the world (World-Health-Organization[WHO], 2005). Low levels of stress can benefit individuals, but high and persistent levels of stress, becomes harmful and resulting in numerous physiological and psychological health conditions (Shah et al., 2015; Wilson, 2009). Stress management by people is done in several ways which include: meditation, physical exercise, progressive relaxation techniques, biofeedback methods, deep breathing, visual arts or imagery, massage and *reflexology*. Reflexology being the centre of this research has attracted a recent wave of public interest, investment and research, making it one of healthcare's research top priorities (Robinson, Lorenc, & Lewith, 2011). by Subha, Joseph, Acharya U, and Lim (2010) described reflexology as is a natural healing art, based on the premise that there are reflex points on the human hands and feet, which correspond directly to other body parts. Generally, reflexology can be performed on the human's hands, ears or feet, but most reflexologists prefer to work on the feet as the feet are larger, more sensitive and are easily accessible (Ebadi, Kavei, Moradian, & Saeid, 2015; Embong, Soh, Ming, & Wong, 2015)

Foot reflexology has been used widely for numerous benefits such as stress relief, distress, enhanced alertness, potential diagnostic tool, and as a complementary treatment tool which has been tested and proven effective in numerous studies (Choi & Lee, 2015; Ebadi et al., 2015; Hudson, Davidson, & Whiteley, 2015; Sahbaee, Abedini, Ghandehari, & Zare, 2015; Samuel & Ebenezer, 2013; N. Stephenson, Dalton, & Carlson, 2003) The relaxing characteristic of foot reflexology treatment makes it suitable for insomnia in antenatal inpatients, and hypertensive patients. Tiran (1996) concurred that when combined with a foot massage, the therapy it can be effective in reducing blood pressure and the physiological Oedema experienced by a lot of women during their early postnatal days. The demands and desire of people wanting to be more in control of their own health have fuelled the increase in the practice of reflexology in health care (Tiran, 1996). This has led to the several attempts made to simulate the interactivity of the therapy in the development of reflexology artifacts and electronically (Himmelstoss, Haas, Strummer, & Votzi, 2007).

Recent researchers have revealed the multimodal interactive nature of reflexology therapy particularly from the patients' and practitioners' perspectives that leads to relaxation and stress relief patients' experience. The study also compare the therapy with alternative application of the therapy (Reflexology Artifacts –RA), and revealed significant potentials virtual reality might offer the therapy. However, the application of the therapy in a virtual space will require further investigation and a proper framework.

1.3 Definition of Concepts

Several essential concepts that will be used throughout this research will be defined in this section.

Integrated: The term integrated is a popular buzz word in computing that refers to two or more components merged together into a single system, to form or blended together into a functioning or unified whole.

Interaction Framework: The interaction framework specifies the major components of VR foot reflexology interaction design and provides design principles and guidance for designers, developers and end users.

Visual interaction: Visual interaction as operationalized in this research focuses on the essence of interaction by which users can carry out tasks on an interactive system using visual tools or elements, then this interactive system provides feedback to the users by representing the results of the tasks the users performed visually.

Aural interaction: With respect to this research, aural interaction refers to these categories of interactivity relating directly to both the active and passive aural interactions that transpire between the practitioner / VR system, the patients / Users, and the environment.

Haptic interaction: haptic interaction in the context of this research focuses on the essence of interaction by which users can carry out tasks on an interactive system using haptic exploration, tools or elements, then this interactive system provides feedback to the users haptically.

Multimodal interaction: Multimodal interaction in HCI focuses on the essence of interaction by which users can carry out tasks on an interactive system using various modalities such as visual and/or aural tools or elements, then this interactive system provides feedback to the users by representing the results of the tasks the users performed haptically, visually and/or aurally.

1.4 Problem Statement

Reflexology has been tested and proven effective in countless studies to improve quality of life and well-being, which is reflected in numerous benefits like stress relief, potential diagnostic tool, distress, insomnia relief, sleeping disorder and as a complementary treatment tool (Abbaszadeh et al., 2018; Bakir, Baglama, & Gursoy, 2018; Choi & Lee, 2015; Ebadi et al., 2015; Hudson et al., 2015; Meghashri, 2018; Sahbaee et al., 2015; Samuel & Ebenezer, 2013; Shahsavari, Abad, & Yekaninejad, 2017; Véron, Balestra, Berlémont, Lanquart, & Jurysta, 2012; Yılar Erkek & Aktas, 2018). Embong et al., (2015) highlighted that other pertinent issues in reflexology are yet to be explored such as the reflexology mechanism, psyche, and the participants' experiences of receiving reflexology. Virtual reality is a potential mechanism or application to administer reflexology stress therapy to patients, but research in the area of stress and depression therapy in VR are still at the infancy stage (Jerdan et al., 2018). Hence, this necessitates the need for a VR interaction framework in foot reflexology stress therapy domain.

The current research state implies that VR by itself cannot be a clinical tool but rather has its triumph reliant or dependent upon the content it provides a platform for; i.e., adaptability and flexibility of its environments allow the content of the intervention technique to be explored further (Jerdan et al., 2018). This led the aforementioned authors to highlight that VR in stress and depression domain is currently at infancy as there is a lack of studies surrounding that domain that have been carried out, highlighting the literature gaps that still exist. Hence, recommending future research to explore it further. Researchers particularly recommended future studies to look into incorporating more mobile forms of VR as VR systems over the last decade have become more available, less costly and generally with improved usability (Jerdan et al., 2018; Parsons, 2015; Parsons & Rizzo, 2008).

An increasing number of patients these days prefer home or self administered treatment, to help improve performance in our daily life (Embong et al., 2015). Hence, encouraging further research to be conducted on how foot reflexology can be provided for these patients at their homes, offices, medical centres and other places with the appropriate, certified techniques (Embong et al., 2015; Stephenson et al., 2003). According to Stephenson et al (2003), further studies need to be carried out as the authors underlined that many family members of the reflexology patients showed interest in learning how to administer reflexology to their patients. Locally, reflexology artifacts (RA) or devices/stimulators are utilized as an alternative to the reflexology practice. This allows a person to attempt self-administered reflexology treatment that does not incur a lot of cost over time, and making a head way to addressing the above issue. This also offers the medical industry the opportunity in complementary and alternative medicine to provide reflexologist's with additional therapy toolkits.

Reflexology is being a form of complementary and alternative medicine (CAM), is a therapy treatments used either as supplementary to or in the place of conventional medical treatment. Singh and Edzard (2008) concurred that complementary and alternative medicine has seen a worldwide investment amounting to an annual estimate of $40 billion. An estimate of £1.6 billion is spent annually in the UK alone as seconded by Ernst (2009). Literature has shown the remarkable public and research driven investment in the therapy, as can be seen in Norway (NIFAB, 2007), Denmark (ViFAB, 2005) and the UK (The House of Lords Select Committee for Science and Technology, 2000; Ernst, 2009), being amongst the top six procured CAM therapies. In an illustration given by Jones and Leslie (2012), procuring a single reflexology session can cost from £15 (€18) (RM45) - £70 (€84) (RM210) per treatment. And as recommended by Rossana (2010) and Smallwood's report (2010), about 6-8 sessions are usually recommended by therapists in order to gain the optimal therapeutic results. This implies that it will cost an estimate of £400 (€480) (RM1200) for an eight-week session, and annually about £1000 (€1195) (RM3000) for repeated blocks of treatment which is the case for chronic health patients (Ernst, 1997). It is as a result of this public-driven investment that reflexology product quality and safety have become one of healthcare's top research priorities (Robinson et al., 2011). This underlines the significance of this therapy, and a practical credibility of this research as it aims at proposing a framework which will guide the application of reflexology therapy in a virtual space.

Recent researchers have explored and revealed the multimodal interactive nature of the reflexology therapy particularly from the perspectives of patients and reflexology practitioners that births the relaxation and stress relief patients' experience, and how much each component contributes to the relaxation and stress relief patients experience. The study also compare the therapy with alternative application of the therapy (Reflexology Artifacts –RA), and revealed that RA is challenged by conspicuous limitations and proposed VR as a suitable alternative to effectively address these challenges (Chimeremeze, Sulaiman, & Foong, 2014). This revealed the potential of foot reflexology therapy using VR technology. However, the application of the therapy in a virtual space will require further investigation and a proper framework.

Frameworks in interaction research have seen varying forms and compositions from numerous researchers and have been applied for either specific of general purposes in several domains. For instance, Kopp et al. (2004) proposed a framework for analyzing iconic gestures and generating novel iconic gestures for embodied conversational agents in multimodal interfaces. But its applicability and generalizability to other application domains is questionable, especially in the context of this research. Boussemart et al. (2004) also proposed a framework for bimanual gestural interfaces in 3D visualization and manipulation in an immersive virtual environments, which was built around a virtual interface widget called ‘pieglass’. Despite being in a VR domain, however the research focused only on the pieglass features, making the framework quite limited. Thus, it is not applicable and generalizable to other domains. Latoschik (2001) developed a software framework for gesture detection and analysis. However, the framework is an algorithmic framework rather than an interaction framework.

In addition to that, Angkananon and colleagues conducted a series of studies and pointed out that most frameworks are incomplete as the reviews they conducted on interaction frameworks revealed that most frameworks usually concentrated on either people-people communication and interaction alone, or technology to enhance communication (Dix, Finlay, Abowd, & Beale, 2004; Sung, Chang, Hou, & Chen, 2010), and miss out on some important interactions like the interaction between people technology and real objects, or People-People interaction, People-Objects interaction, People – Technology interaction, People-Technology-People interaction, People-Technology – Objects interaction (Angkananon, Wald, & Gilbert, 2013c, 2013a, 2013b, 2014). All or part of which are significant components that must be considered for a multimodal interaction framework for VR foot reflexology stress therapy application. Previous research have underlined the potential of VR can offer to the reflexology therapy. But in order to propose a framework for VR-foot reflexology therapy, a few questions have to be answered by the research. What components make up the multimodal VR-FRST framework? How effective will this proposed VR foot reflexology framework be on relaxation and stress relief?

1.5 Research Questions

The 3 main research questions that correlate to the problem statement are listed as follows.

i. What are the components of the integrated multimodal interaction framework for Virtual Reality Foot Reflexology Stress Therapy?
ii. How can we design and develop an integrated multimodal interaction framework for VR-FRST using the identified components?
iii. How effective is the integrated multimodal interaction framework for Virtual Reality Foot Reflexology Stress Therapy on relaxation and stress relief?

1.6 Research Objective

i. To determine the components of the multimodal interaction framework for Virtual Reality Foot Reflexology Stress Therapy.
ii. To develop a multimodal interaction framework for Virtual Reality Foot Reflexology Stress Therapy using the identified components.
iii. To evaluate the effectiveness of the multimodal interaction framework for Virtual Reality Foot Reflexology Stress Therapy on relaxation and stress relief.

1.7 Scope of the Research

This research extends the previous research that explored the traditional reflexology therapy to identify the existence of multimodal interaction in the therapy; hence the focus is now shifted toward the framework development for VR foot reflexology therapy, which will lead to the design and evaluation of the framework and prototype as proof-of-concept. However, the research focus is moved beyond just the haptic interaction of this haptic dominant therapy as has been the only focus of past research and existing market products listed in Table 2.4 and as can be seen in (Himmelstoss et al., 2007) and traditionally as can be seen in reflexology artifacts (RA) (Okere, Sulaiman, Rambli, & Foong, 2015). This research focuses on the identification of the framework components in VR foot reflexology therapy for relaxation and stress relief. These components would be utilized to design a prototype which will be tested for its impact on relaxation and stress relief.

Hence, to avoid any misperception or misinterpretations, there is a need to outline that this study abided by specific research scopes as follows.

i. The geographical region of this research is Malaysia, hence reflecting the following points.

    - The respondents involved in this study were either Malaysians or other nationals studying or working in Malaysia at the time of this study.

    - English language is the only medium used in writing and designing the content of the prototype.

    - The rules and guidelines followed in designing and executing the prototype were derived from the outlined framework components identified from the early phases of this research.

i. The prototype VRFootReST was developed based on these criteria:

- The targeted device was Android Smartphone HMD. This implies that other devices (wearable, hand-held or mobile/immobile) are beyond the scope of the study.

- The Android SDK and Unity 3D are used as development tools to design, code and develop the visual and aural components of the prototype while the haptic component was represented by the reflexology artifact (reflexology slippers).

ii. The study is concerned with the evaluation of the proposed multimodal interaction framework for virtual reality foot reflexology stress therapy application. The evaluation process was conducted as follows:

- The prototype testing was done using 2 sets of experts HCI or of similar background, and medical or complementary therapy experts.

- The prototype was evaluated to reveal the effectiveness of the prototype on relaxation and stress relief.

1.8 Research Significance

The main significance of this research project is listed as follows.

- The study contributes to the field of interaction design by proposing an integrated multimodal interaction framework for virtual reality stress therapy application.

- From a medical or complementary therapy perspective, it has been underlined that as a result of this public-driven investment that reflexology's product quality and safety have become one of healthcare's top research priorities (Robinson et al., 2011). This research contributes to the knowledge body as it proposes the utilization of virtual reality as an alternative to foot reflexology therapy, and for stress and relaxation practice. This will potentially allow users or patients to undergo reflexology treatment using VR for stress and relaxation therapy.

- Stress as declared by World Health Organization is a global epidemic. Stress and varying relaxation techniques or approaches have long being examined and researched upon (Smith, 2007b). This research also contributes in this capacity as it proposes the utilization of virtual reality application to combat stress.

- From a computing perspective, it has also been underlined by researchers that virtual reality in stress and depression domain is currently at infancy as there is a lack of studies surrounding that domain that have been carried out. This research contributes to this gap by proposing an integrated multimodal interaction framework to be utilized in virtual reality for foot reflexology therapy, or related relaxation and stress therapy practices.

1.9 Thesis Structure

In general, this research consists of seven chapters. The following summarizes the contents of every chapter:

CHAPTER 1: INTRODUCTION – The chapter introduces the main subject of research, highlighting the research background, problem statement, research objectives, and the rationale behind undertaking the research, and finally the thesis structure.

CHAPTER 2: LITERATURE REVIEW – The chapter discusses a thorough review of past and current related literatures on the key concepts, theories, and relevant domains, which are in line with the research objectives.

CHAPTER 3: RESEARCH METHODOLOGY – The chapter reveals in details the research methodology employed in achieving the outlined research objectives. It highlights the research design, research activities in each research phase, sampling and data collection techniques for the studies, and finally, data analysis.

CHAPTER 4: MULTIMODAL VR – FRST INTERACTION FRAMEWORK – The chapter presents how the SLR led to the identification of the framework components, and the development of the proposed framework for multimodal interaction in virtual reality foot reflexology therapy. The chapter detailed out the exact content of each component in the framework. The chapter concludes by discussing the validation process of the proposed framework by experts.

CHAPTER 5: PROTOTYPE DEVELOPMENT AND EVALUATION FOR RELAXATION AND STRESS RELIEF – The chapter reveals the prototype development and evaluation for relaxation and stress relief which will lead to answering the 3rd research objective. The chapter also presents the prototype demonstration to medical and complementary therapy experts to provide insights using their expertise on the prototype's effectiveness, safety, internal components, psychological and physiological implications, and an overall overview of the prototype before it is being tested on users

CHAPTER 6: VR-FRST EVALUATION FOR RELAXATION AND STRESS RELIEF – The chapter reveals the proof of concept of the effectiveness of VR foot reflexology stress therapy for relaxation and stress relief. A quasi-experiment was adapted to evaluate the prototype on users in a pre and post test evaluation process. Consequently, the chapter presented the analysis and results of the prototype on the selected relaxation and stress relief variables.

CHAPTER 7: CONCLUSIONS – The chapter highlights the summary of the research outcomes. The chapter outlined the findings that addressed each of the research objectives. The chapter also presents the research contribution to the body of knowledge, the research's limitations, and finally recommends further undertakings future research should explore.

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

This chapter presents similar researches from related domains, primarily from virtual reality (VR), VR stress therapy, alongside foot reflexology and their significance. A detailed review of existing theories, concepts, models and principles in the related domains like multimodal interaction, design principles, ABC theory, and information architecture were also explored. It also presents reviews of empirical works on the multimodal interactions of virtual reality stress therapy applications.

2.2 Virtual Reality (VR) and Modalities

VR technology is the combination of AI technology, multimedia technology, computer networks technology, computer graphics technology and designed into a new HCI technology through which users can experience and interact with 3D environment using visual, auditory, haptic, taste, and so on interactions, similar to real-world experience (Wu, Liu, Wang, & Zhao, 2015).

The utilization of VR has been effectively exploited, adopted and employed in varying domains to address several challenges. VR is employed in education and training (Solak & Erdem, 2015; Wu, Wang, Zhao, & Wu, 2015; U. Yang & Kim, 2002); VR in engineering and automobile industries is particularly popular (Berg & Vance, 2017; Nutakor, 2008; Sandino, 2012). VR is also employed in scientific discovery (Johnston et al., 2017); the gaming and entertainment industry is the most prominent and successful domain that VR has flourished (Choo & May, 2014; Liszio

& Masuch, 2016). VR is effectively employed in the medical and healthcare industries (Johnston et al., 2017; Khan et al., 2017; Taneja, Vishal, Mahesh, & Geethanjali, 2017); also in the treatment of phobia through VR exposure therapy (VRET) and other domains of therapy and rehabilitation (Brinkman, 2012; Cardoş, David, & David, 2017; Lindner et al., 2017; Menelas, Haidon, Ecrepont, & Girard, 2018; Morina et al., 2015a; Patterson & Nanni, 2015; Scapin et al., 2018). Multimodal interactivity is exploited in VRET to enhance the anxiety-producing stimuli, increasing or decreasing the effect of these stimuli on patient while the therapist assists them through the process of overcoming their phobias. The stimuli referred to here are produced by patients as a consequence of their irrational fear of a particular situation or condition like the fear of flying, fear of heights, agoraphobia, fear of driving, fear of spider, fear of public speaking and so on. Using VR exposure therapy, permits the therapist to control the amount or intensity of the induced anxiety through the adjusting of the multimodal parameters in the virtual environment by increasing or decreasing the fear factor to equal the patient's tolerance level. This enhances the patients' sense of presence and immersion (Cardoş, David, & David, 2017; Cukor et al., 2015; Parsons, 2015; Patterson & Nanni, 2015; Albert Rizzo et al., 2015; Zinzow et al., 2017).

Research into modality has seen several definition of the term in related domains. Wechsung (2014) concurred that these domains can be categorized into physiological or human-oriented definitions, system or technology-oriented definitions, and that which incorporates both views. Modality originated from physiology and defined as the "perception via one of the three perceptual channels"

(Charwat, 1992). In the physiology of senses, the three modalities can distinguished as visual, auditive or aural, and tactile or haptic. In other words, these three aforementioned senses are the human sense of touch, hearing, and sight, which corresponds to the three channels of perception (Charwat, 1992; Wechsung, 2014).

However, in recent times particularly in Human-Computer-Interaction (HCI), at least three more senses of smell, vestibular, and taste are defined in physiology. Bernsen (2008) offered another definition of modality, moving away from the physiological understanding of modality, and described it as a way of representing information in some physical medium rather than through the human senses. He explained further that people utilize numerous ways to represent information and these numerous ways may refer to the same human sensory modality. For instance, images and text are different representation means despite both equally referring to human sensory vision. Consequently, a multimodal system based on Bernsen's description is a system that employs at least two different modalities (i.e., ways of information representation) for input and/or output.

Similarly, Al-Aidaroos (2017) concurred with Wechsung (2013), referring to multimodal interaction as more than one ways to interact with a system, and providing several distinct methods for inputting data.

Another definition of multimodal system was given by Oviatt (2002) as systems processing of two or more combined user input modes like speech, pen, touch, head and body movements or gestures, and gaze in a coordinated manner with multimedia system output. Hence, Oviatt's description of modalities refers to input modes, contrary to the above mentioned definitions which explicitly refer to the term modality. Consequently, modality in terms of this research, adapts the original Charwat's (1992) description of the utilization of sensory channels or the human senses of sight, hearing, and touch to interact with a system for input and/or output.

Multimodal interaction can be inferred from Dumas et al (2009) and Sarter (2002) as the equipping of users with multiple choice of modalities to interact with a system that reacts and interprets to users' inputs from more than one modal and interaction channel, be it through aural, gestural, gaze, facial expression, body movement, and touch. Jacobson, Kitchin and Golledge, (2002) also added that multimodal interaction in VR consist of interaction through several interactive input and display devices like keyboards, joystick, mouse, monitor, alongside other peripheral devices for speech recognition, eye gaze tracking, gesture tracking, data gloves, tactile feedback from surface textures, head mounted displays, force feedbacks, etc. The authors added that VR presents the opportunity improve the quality of life by offering a platform for enhanced education and mobility, which creates the avenue for work and leisure.

Reeves et al (2004) explained that the two main aims of multimodal interactions are to achieve an interaction closely similar or identical to the natural human-human interaction style, and to increase the interaction's robustness through the use of redundant complementary information. Touch (haptic), sound (aural), and sight (visual) presents the best multimodal or sensory options in VR systems development. This is justified by the fact that most of the works and resources in this domain, centre of attention have been on exploring these three sensory modalities, limiting this research's focus to these three VR sensory modalities: haptic, aural and visual interactions.

Attempting to represent large amount of information within one modality could be disastrous or overload users' cognitive resources associated with that modality (Walvoord et al., 2008; Wickens, 2002). However, such information presented using multiple modalities like haptic, visual and aural sensory modality, is less likely to overload users' cognitive system needed to process the information (Walvoord et al., 2008; Wickens, 2002). Combining several modalities always presents the best outcomes to execute and complete tasks faster, easier, and efficiently. The same is the case in VR and user interaction interfaces, the combination of several multi-sensory modalities have proven advantageous such as enhancing realism, improving users' experience, stimuli intensity control like in Virtual Reality Exposure Therapy (VRET), improving users' task performance efficiency, and enhanced interactivity and engagement (Walvoord et al., 2008; Strickland, 1997; Storms & Zyda, 2000; Wickens, 2002; Freeman, & Lessiter, 2001).

Hence, visual modality, aural modality and haptic modality are the three main interactive modalities in VR as have been highlighted by the majority of the aforementioned authors (Wu, Liu, et al., 2015). The follow sections present the varying modalities and their interactive natures.

2.3 Visual Modality

HCI as defined by the Association for Computing Machinery, is "*a discipline concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them*" (Hewett et al, 1992). The acronym HCI stands for Human-Computer-Interaction and is occasionally substituted for and referred to as Human-Machine-Interaction (HMI), Man-Machine-Interaction (MMI) or Computer–Human-Interaction (CHI). Any of the aforementioned permutation underlines the significance of the interaction between people and computers as well as safeguarding and guaranteeing users' satisfaction. The interaction aspect involves a user input, system capture through input device, processing, interpretation, and then feedback or output.

The Oxford advanced dictionary describes "*Interaction*" as mutual or reciprocal action or influence of two objects. It is a kind of action that occurs as two or more objects have an effect upon one another. The idea of a two-way effect is essential in the concept of interaction, as opposed to a one-way causal effect. The feedback during the operation of machines such as a computer or tool, for example, the interaction between a driver and the position of his vehicle on the road: by steering the driver influences this position, by visual observation this information returns to the driver.

Multimodal interaction in HCI focuses on the essence of interaction by which users can carry out tasks on an interactive system using various modalities such as visual and/or aural tools or elements, then this interactive system provides feedback to the users by representing the results of the tasks the users performed haptically, visually and/or aurally.

Visual interaction in the computing world, is one of the most common and significant mode of interaction. For instance, operating Microsoft Windows calculator with a mouse, it is user-friendly and easy to use. Now the same operation with the user's eyes closed can frustrate the user without visual interaction, despite this task not being so different from dialing a touch tone phone which most of us can complete closing both eyes.

Jacobson, Kitchin and Golledge (2002) describes interaction as the extent to which users can play or alter with a representation which can either be closed-loop (the user can interact and navigate through the display and alter information sequence) or open-loop (the entire display runs from start to completion) in nature.

The operationalization of visual interaction from this research's perspective refers to the essence of interaction by which users can execute commands on an interactive system via visual elements or tools, then receive feedback or output from the interactive system through the representation of the output visually. Poggi and Di Blas (2006) particularly concurred that VR is a "visual" technology, capable of the representation of virtual objects from another perspectives, and permitting users' interaction and manipulation.

Virtual reality is dependent profoundly upon the visual presentation and display, and hence, it is not surprising that visual interactivity becomes a significant modality amongst other modalities, and a valuable modality for understanding space as seconded by Foulke (1983). Ultimately, there is no VR experience without some sort of visual interaction. For example, geographic representations are generally visual; making people's ability to see paramount so as to perceive and explore these virtual environments. Hence, visually impaired or blind users would find it difficult or impossible to access or navigating the virtual environments (Jacobson, Kitchin & Golledge, 2002). Jacobson, Kitchin and Golledge (2002) also expressed that the augmentation of visual representations is the ultimate aim for multimodal interaction and not so much for the visually impaired. Visual interactivity in VR offers several benefits beyond just what some users called an adventure in unfamiliar territories like the sense of presence, immersion, involvement and engagement, suspension of disbelief, and peripheral awareness.

Immersion is a quality visual modality presents in VR where users in a virtual world perceive and have a realistic feeling of "being there", being somewhere else, somewhere different from where they actually are. This phenomenon is referred to as "Virtual presence" (Malińska, Zużewicz, Bugajska, & Grabowski, 2016; Wu, Liu, et al., 2015; Wu, Wang, et al., 2015), which encourages the suspension of disbelief. Immersion is also seen as the extent to which a system's visual interactions have the capacity to convey an inclusive (the degree at which physical reality is shut out), extensive (the variation of sensory modalities available), surrounding (the degree of panoramic view in VR rather than the limited narrow fielded view), and vivid illusion of reality (referring to the richness of the VR information content, displays quality and resolution).

Presence refers to the psychological conscious states of being in a VE. Presence have being explored by countless researchers in the last two decades (Diemer, Alpers, Peperkorn, Shiban, & Mühlberger, 2015; Murray, Neumann, Moffitt, & Thomas, 2015; Peperkorn et al., 2015; Wu, Liu, et al., 2015; Wu, Wang, et al., 2015).The ultimate goal of the concept of "*presence*" is to have users experience virtual environments as more engaging as compared to their surrounding physical environment, as well as, consider the VE's explored environment as visited places rather than images seen (Slater & Wilbur, 1997).

The sense of presence or immersion is relatively essential in stress and relaxation therapies. This is so because these qualities boost the patient's emotional or psychological responses. VR technologies involving HMDs, motion-tracking displays, with 3D computer-generated environments that are realistically rendered, giving the chance for researchers to simulate or recreate phobic stimuli, through the manipulation of significant variables that relates to that particular stimulus like (movement, colour, texture, and size), scheduling, context and degree of exposure intensity based on the patient's currently acceptance threshold (Lindner et al., 2017; Morina et al., 2015; Bush, 2008).

Suspension of disbelief refers also to a quality visual modality presents in VR where users visualize a VE as real with little disbelief, especially not being startled out of this particular state by the VE's behaviour (Bates, 1991). Different from the usual computerized flat-screen displays, virtual reality systems or application are known for their higher intensity of user-system immersion and interactivity. This amplifies the suspension of disbelief required to create the sense of presence in Virtual Environments (Rizzo & Kim, 2005).

Involvement and engagement refers also to a quality of VR where by the user believes to be part of his virtual environment, and engaging in those VE activities as they would a real life activity with enhanced sense of presence.

Peripheral awareness refers also to a quality of VR where by users may wish to look around at any point to see where or what everything/everyone else is up to (Poggi & Di Blas, 2006).

2.3.1 Visual Interaction and Well-being

The utilization of VR as an intervention technique to ease and alleviate the symptoms of fatigue, distress, and anxiety in breast cancer chemotherapy receiving patients can be seen from the study of Schneider et al (2004). The authors found out that there was a noteworthy reduction in the fatigue symptoms, anxiety, and distress which took place immediately with the utilization of VR intervention.

Researchers concurred that guided image therapy is a common technique generally established and used in psychotherapy for relaxation (Awang et al., 2011). The guided image therapy encourages the state of focused concentration, permitting patients to relax, clear their minds, and engage in healing using visual interactions that improves both physiological and psychological wellness. This then helps patients combat stress, depression, anxiety and strengthening their immune system (Tusek et al, 1997).

Awang et al. (2011) exploited the potential and possibility of visualization and visual interaction to develop a VR application called "VReST" which allows user to select images they want from a list of VE selection to explore and utilize the location during the course of the therapy. This is done by combining visual and aural interactivity, rather than just imagining being at the location. From the context of this research, this can be related to the ultimate goal of relaxation and stress relief through VR foot reflexology. The prototype integrated visual stimuli, cues and interaction as revealed during the user requirements gathering process which encourages users' relaxation and stress relief.

In HCI as expressed by Matera (2009), visual interaction is the utilization of user interfaces for interactive systems, making use of the visual elements and visual interaction techniques to support perceptual inferences rather than challenging computations and cognitive comparisons. Designing visual interaction centres on the interaction mechanisms definition whereby (i) a user may perform tasks on a interactive system via visual elements, and (ii) the system processes and present the result of processing or feedback via visual representations. That is to say, Matera (2009) expressed visual interaction with an interactive system to be performed via visual elements as input, this interactive system captures and processes these users' input, and outputs the result of processing to the users.

The proliferation of computer vision and visual interactions has encouraged innovative methods of interacting with digital environments (Vartiainen, Chande, & Rämö, 2006). The aforementioned authors expressed that the system uses computer vision to capture users' gestures, movements, or motions and process them as a stream of images. In a conventional interaction between people, they communicate and express themselves sometimes using several nonverbal communications which also carries rich information. This is also described in the Oxford's advanced dictionary that gestures are the movement of body parts, especially the hand or head, to express or lay emphasis on an idea, feeling, meaning or intention. This implies that, human gestures are perceived by the observer as a series of visual images or content which carries embedded information, sentiment, attitude, emotion, or feelings. This phenomenon is consistent with and concurred by several researchers (Vartiainen, Chande & Rämö, 2006; Pavlovic, Sharma & Huang, 1997; Matera, 2009; Micilotta & Bowden, 2004). From the perspective of this research, the VR system is the observer in this context, visually capturing users' gestures during the course of the therapy, gathering and interpreting series of visual cues which will alter the course of the therapy. Hence, the identified visual cues in therapy captured by the system from the patients' or users' perspective is identified and would act as input commands to be processed by the VR system.

2.3.2 Visual Motion Recognition and Capture

Facial recognition and capture have been utilized in many different applications and domains which animation, gaming, human-computer interaction, security and telepresence as seconded by Chen, Wu, Shi, Tong and Chai (2013). In the domain of visual recognition and capture, particularly in the area of facial recognition and capture, the maker-based motion capture is one of the most thriving techniques for 3D facial performance capture which vigorously and precisely tracks sparse set of markers attached on the face (Grimm Cindy, 2008). Recent studies in this domain have focused on complementing marker-based motion capture with capturing devices like video cameras and/or 3D scanners to enhance the resolutions and details of captured facial geometry (Bickel et al., 2007; Huang, Chai, Tong, & Wu, 2011). However, the practicality of marker-based facial capture is not feasible as argued by researchers especially for random users (Chen et al., 2013). On the other hand, marker-less motion capture offers a tremendous alternative to facial capture because it is non-intrusive, does not require the subjects to wear marker devices or attachments, and also does not impede the subject's ability to perform or function normally.

The animation and gaming industry is one of the industries that heavily utilizes this technology which involves interaction with avatars for communication or education, to make them look more realistic and attractive (Reverdy, Gibet, & Larboulette, 2015). The authors added that using real captured human motions on real actors offers the ability to animate virtual characters with credible behaviours, reinforcing their easy comprehension and acceptability. Aural modality and the nature of its interactivity is presented in the next section.

2.4 Aural Modality

Aural interaction alone in HCI provides a host of immeasurable advantages, especially in disability or for visually impaired users. For instance, in the navigation of a web page, as we may well know, audio is a serial form of data presentation and by its nature, listeners take a passive role during navigation in listening to all the system has to say before taking action unlike the active role taken by visually enabled interaction, where the sighted viewer can opt where and where not to read, view or focus on. Another challenge aural interaction faces is the difficulty in representing graphical data in audio form “data sonification” (Rollins, 2000).

These setbacks make aural interaction not to be as dominant as its visual and haptic modal counterparts. But pivotal in the optimization of efficiency and effectiveness in user interface interaction when put alongside other modalities. The study of Le Groux, Manzolli and Verschure (2007) examined the complexity of sonifying a mixed reality space . The authors argued that sonification is crucial to feelings of immersion, and noted the difficulty of sonifying a virtual space in terms of soundscapes, synthetic voices, and dynamic emotive music.

In people's daily lives, especially the visually impaired, they use all their senses to interact with the world; they can tell when a car drives alongside the sideway, they can tell when it stops at a traffic light or when it is far away through the means of echolocation they hear the difference between covered and open spaces (Infomap Volwassenen, 2007). Aural perception is omnidirectional unlike any other sensory modality; for instance, visual perception gathers an enormous amount of information but from one direction at a time as seconded by Jacobson, Kitchin and Golledge (2002). The author also highlighted that aural interaction enhances user interest and engagement by increasing the user's enthusiasm, reducing the user's learning time and fatigue Jacobson, Kitchin and Golledge (2002).

2.4.1 Aural Interactivity in Entertainment and Virtual Reality

Aural interactivity carries with it the sense of presence or activity, giving one the sense of being in the company of someone, something or an activity. For instance, exploring an environment in a virtual world, walking down a street or using a character to walk down a street, the activities of other characters can be inferred from the sounds they are making: blacksmiths are pounding hammers on anvils; passing cars generate positional engine noise, and so on. There is a sense of on-going activities despite not being able to visualize the character or the activity. Aural interactions, be it through music or other means makes a person to feel less alone (i.e., connected with something/someone else) or remind the person that an on-going activity is still going on (continuity), albeit been distracted momentarily by something or someone else (Parker & Heerema, 2008). The author also highlighted that aural interaction is known to carry more emotional content than any other modality that is to say that, sounds trigger feelings and memories. It is said by psychologists that humans learn first by seeing, next by hearing. However, the sense of hearing connects to the limbic system, where memories can be recalled using sounds like music and voices, and loud and sudden sounds cause an immediate startle reflex in fear (Brown, Martinez & Parsons, 2004; Winer, 2006), like the rumbling and growling sounds of a wild animal would trigger a fearful emotional response.

In fact, aural interactivity can generate fear emotion even more than vision in some case. For instance, seeing a predator in close range would probably be less of a threat because the degree of threat can be measured and anticipated, as compared to, if it can only be heard in close range. You would surely not be able to know what to anticipate i.e., a prey that can only hear the sound of a close proximity predator is in an unknown amount of trouble. A sudden sharp noise would trigger a surprise emotion, which would usually make the hearer react instinctively (Brown, Martinez, & Parsons, 2004; Parker & Heerema, 2008; Winer, 2006). Loud noises that are close enough are generally big enough to be a real danger (Winer, 2005); hence, it is certain that certain sounds would affect us at a profound emotional level which designers usually utilize to provide an interesting emotional experience in Virtual Reality.

As we well know, aural interactions cannot be ignored as easily as we would visual interactions. People use aural interactivity directly for communication to a greater degree than any other modality especially with the ability people have to distinct or isolate one sound out of many simultaneous sounds and concentrate on it.

Speech is utilized in gaming and virtual environments which entail human-like characters to communicate information to the users in a natural manner (Parker & Heerema, 2008). It may involve a direct active conversational interactivity or a passive overhearing of conversations to share valuable information with the user.

Sound effect is utilized in entertainment and virtual environments to serve several purposes. They include both predictable and user triggered sound (Serafin & Serafin, 2004), such as footstep of someone approaching, a door opening or a confirmation that an event has taken place (Parker & Heerema, 2008), like a gunshot sound from squeezing the trigger of a gun to confirm that the shot has been made.

Ambience is another aural interactivity in entertainment or virtual environment that helps in enhancing immersion and the sense of realism which is very different from sound effect in that they are background sounds that present the sense of atmosphere. For instance, the nearness to the ocean or river is usually heard before it's seen, or the sound of the winds blowing or street noise and so on. In entertainment like the movie industries, sound effects and ambience are being exaggerated to create an immersive experience, whereas in virtual environment, it is utilized to immerse the users in a state where they experience a phenomenon known as "suspension of disbelief" (Parker & Heerema, 2008; Serafin & Serafin, 2004).

With respect to this research, these categories of aural interactivity relate directly to both the active and passive aural interactions that transpire between the practitioner, the patients, and the environment. The aural interactivity from both the patients' and the practitioners' perspective involved in the therapy that alters/encourages the course of the therapy would likewise be identified. Subsequently, these identified aural interactive natures of the therapy would act as design guidelines for future virtual reality foot reflexology stress therapy application or related application/domain.

2.4.2 Aural interactivity, Health, and Well-being

Aural interactivity has been instrumental in several domains for several purposes, even in rehabilitation and stress relief, which can be seen in how people use music in their everyday lives. Music for most people is more likely to be an element of comfort, source of inspiration, distress, expression of feelings, positive distraction, entertainment or company (Buchanan, 2013), i.e., performing a different task with music alongside as companion (for instance, dressing up for work, driving to or from work, some use music during physical exercise) rather than being the primary focus. In fact, in the extensive practice of music therapy in medicine and health care in the treatment of ailments like Alzheimer's disease and cancer (Barrera, Rykov, & Doyle, 2002; Buchanan, 2013).

In the last decade, extracting vast information from music through listening was energized by Dura (2006) and Reimer (2004), in their neuroscience and discoveries advancement about the dramatic effect and development of music on emotions and cognition. In 2004, Reimer described Damasio's assertion that emotions are generated by the brain, and feelings are generated by the body. Emotion being the basis of feelings carries emotions to another level of experience, from the brain to the body, consequently connecting the two together, creating a conscious awareness of emotion in the course of the bodily act of feeling (Reimer, 2004). Ganz Cooney, the creator of "Sesame Street" explored the feasibility of using television as an educational tool, and discovered that children watch large amounts of television and react to humour, music and interesting visuals (NewYork-Public-Library, 2015).

Studies have shown effects of music on the quality of life, feelings expression, socialization, involvement with the environment, and positive association (Vanderark, Newman & Bell, 1983; Smith, 1990; Prickett, 1988). In fact, there is a science called music therapy by which music is been employed as a positive stimulus in relaxation, pain, anxiety and stress relief (Buchanan, 2013; Daniel, 2016; Powell, 2016; Tam, Lo, & Hui, 2016; Trapp, Engel, Hajak, Lautenbacher, & Gallhofer, 2016). With respect to this research, the VR-FRST system will also incorporate a form of music therapy for the passive aural interaction, influencing the relaxation and stress relief experienced by the patients. The identified aural interactive nature from the therapy outlined in the design guidelines from the previous study is incorporated into the VR-FRST prototype at the design and development phase. The next section presents haptic modality and the nature of its interactivity.

2.5 Haptic Modality

Haptic research originates with the work of Heinrich Weber (Prytherch, 2002), a 19th-century Professor at the university of Leipzig. The first application of force feedback in a teleoperation system for nuclear environments has been introduced by Goertz at Argonne National Laboratories in 1954. Subsequently, the group led by Brooks at the University of North Carolina at Chapel Hill adapted the same electromechanical arm to provide force feedback during virtual molecular docking in 1990.

The terminology "*haptics*" is a proliferating term in HCI with the growing use of touch in computing. McGee (1999, 2001) concurred that the term used to describe this sense is not as established as it's sensory counterpart (visual and auditory), and therefore lots of terms with diverse meanings are still being used across literatures to refer to haptic interactivity, limiting the consensus and common understanding in the research domain. In remedying that, the author put forward this set of haptic related definitions as shown in the Table 2.1. Haptics have successfully been adapted and applied in numerous domains for various aims.

Table 2.1

Haptic Definitions (Oakley, McGee, Brewster, & Gray, 2000)

Term	Definition
Haptic	Relating to the sense touch.
Proprioceptive	Relating to sensory information about the state of the body (including cutaneous, Kinesthetic, and Vestibular sensations).
Vestibular	Pertaining to the perception of head position, acceleration and deceleration.
Kinesthetic	Meaning the feeling of motion, relating to the sensations originating in muscles, tendons and joints.
Cutaneous	Pertaining to the skin itself or the skin as a sense organ. Includes sensation of pressure, temperature and pain.
Tactile	Pertaining to the cutaneous sense but more frequently the sensation of pressure rather than temperature and pain.
Force Feedback	Relating to the mechanical production of information sensed by the human kinaesthetic system.

2.5.1 Role of Haptic Interactivity

Haptic interactivity through touch provides direct contact with other persons or an object which relies on active exploration (Klatzky & Lederman, 1990) could have various benefits, interpretations and outcomes depending on the context, situation, person, area being touched and so on. Meanings such as: support, appreciation, inclusion, sexual interest or intent, affection, playful affection, playful aggression, compliance, attention-getting, announcing a response, greetings, and departure (Jones & Yarbrough, 1985; Hertenstein & Campos, 2001; Knapp & Hall, 1997; Hertenstein & Keltner, 2011). MacLean (2000) added that by reaching out to touch, our intentions are revealed, we violate taboos and we enter others' personal space; exposing ourselves to physical danger, pleasure or information.

Haptic interaction varies in various contexts, purpose and situation. It can be friendly and welcoming in nature, which is very common in the usual greeting and departure rituals such as handshakes, cheek pecks, hugs, and so on. Haptic interaction can likewise be abusive and aggravating in nature like in the case of pre-school bullying (Push, slap or punch) or being accidentally bumped into, being stepped on without an apology from the person (doer of the action) could aggravate the other person (receiver of the action), which could also be used to express anger (Hertenstein & Keltner, 2011). Haptic interaction can also be seductive, romantic or intimate in nature which is commonly used by sexual partners through the caressing of certain sensitive body parts to induce arousal and anxiety. Even the conventional greeting rituals like hugging if prolonged for a little longer than the usual can be interpreted as a sexual or romantic message as well. This sort of interaction from a close friend, a spouse or a parent expressing closeness provides physical and psychological comfort, emotional support, encouragement, and is usually very appreciative (Hertenstein & Keltner, 2011). Haptic interaction can be very professional as well when work related routines of certain jobs require touch contact by the participants like in the case of some contact sports, medical procedures, etc. It also expresses an agreement to an idea, a deal or a contract. Above all, haptic interaction can be highly therapeutic and relaxing in nature inducing stress relief, such as the application of pressure and/or massaging of certain parts of the body, as can be seen in touch therapies like reflexology, massage, neuromuscular therapy, acupressure, and acupuncture, etc.

All of these were categorized by MacLean (1999) and termed "Communicative Touch" explaining that it involves a consciousness and abstraction that an inert environment cannot provide; which also involves a sender and a receiver (whether deliberate or accidental at either end) that could either be a human, animal or machine, so long as their interaction or their model of interaction conveys a changeable contextual message.

MacLean (1999) continued that people are more cautious about what they touch generally than what they see or look at for the mere fact that they may have a choice whether or not to interact haptically. This is a large part of designing haptic interfaces as the designer must focus on anticipating, accommodating and managing the potential users' perception about the haptic interaction, considering what it is for, and what the experience will be like. This perception often is the reason that motivates or inhibits users from engaging or avoiding haptic interaction. Some reasons that motivate the engagement of haptic interaction can be: to perform a task; to explore something for its status, characteristics, reaction or perceived experience; to relay or communicate a message; for verification of a perceived notion; to connect emotionally or physically with other beings.

Contrary to these foregoing reasons, some other reasons exist that inhibit the users' engagement of haptic interaction are mostly perceptual which can include: the perception that it would or could be filthy, hurtful, a taboo, frightening, unpleasant, fear of an uncertain experience; a set of haptically challenged individuals as Maclean (1999; 2000) term them, explained that some culturally associated individuals do not find touching natural, informative or pleasant.

2.5.2 Benefits of Haptic Interactivity

There are several aims and benefits that are achieved in the course of haptic interaction. Just as Maclean (1999) termed it as "Information Available from Touch", Touch is the principal contributor to a number of high levels, integrated perceptual functions. Information obtained from this sensory system helps in: assessing of an object's dynamic and material properties e.g. (Texture, hardness, weight, size etc. (Lederman & Klatzky, 1987)) or the assessment of other people like a handshake would express social gesture and assess the person's social dominance; verification of engagement and completion like the slipping into gear of an automobile shifter; the continuous monitoring of on-going activity and gradual doneness like the scraping of a pencil by a pencil sharpener relating to progress and completion; to build a mental model for invisible parts of a system or an object in the dark or by the blind. Underlying theories that contributes at any stage of this research is presented in the following section.

2.6 Underlying Theories

The ecological psychology model by Gibson (1986) laid a very significant theoretical foundation for virtual reality. The ecological psychology is the psychology of awareness and activities of individuals or users in an environment (Gibson, 1986; Mace, 1977). This theory of perceptual systems is based on the users' direct perception of the environment. The perceptual theory put forward by Gibson highlighted the "*Affordance*" feature, which distinguishes the entity from other things it is not. This feature aids in perceiving and comprehending how to interact with the entity; allowing users access information through the recognition and relationships amongst objects of contextual conditions. The author lay emphasis on perception as an active process; in that, the various interactive modalities of visual, aural, tactile and other modalities are not viewed as mere producers interaction, but rather as active seeking mechanisms for looking, viewing, listening, touching, and so on, firmly interrelated and operating in tandem. Consequently, visual and aural perception which is usually used to seek visual and sound information orients us in space, and the motor systems enable us navigate and handle the world. Hence, highlighted the significance of understanding the kinds of interactions involved in real or traditional environments; this knowledge from real world informed the design of interactions in the virtual world, allowing the VE interactions to appear natural, realistic and meaningful (Ellis, 1991, 1992; Gibson, 1986; McGreevy, 1993; Sheridan & Zeltzer, 1993; Zeltner, 1992).

2.6.1 The Neuman System Model

Neuman and Fawcett (2002) propose a theoretical framework called the Neuman System Model. This model concentrates on stressors; the interaction between people and their environment, which ultimately contributes to their mental well-being. This model consist of four main features; person, environment, health and nursing (Neuman & Fawcett, 2002; Shah et al., 2015) as shown in Figure 2.1.

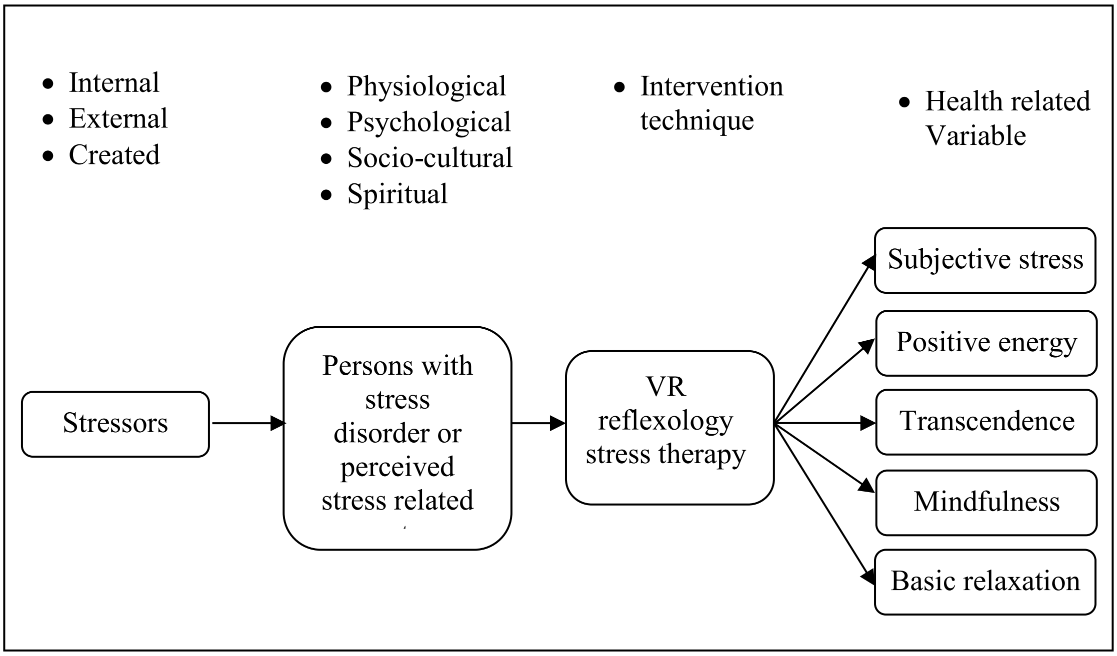


Figure 2.1. Stress and relaxation model guided by the Neuman System (Neuman & Fawcett, 2002; Shah et al., 2015)

Nursing refers profession that assists persons to achieve and/or resume their state of equilibrium (Shah et al., 2015). And in the context of this research, refers to the intervention technique employed to assists users to achieve relaxation state and/or stress relief. Environment could be either internal, external, or created; and are usually the source of stress to a person; and without proper management of these stressors, they may disrupt the person's equilibrium, contributing to poor health, delayed recovery, depression, anxiety and so on (Shah et al., 2015). In the context of this research, a person refers to people or users experiencing a lot of stress from daily interaction with this environment. And health is the level of objective and subjective stress, and perceived level of relaxation. Shah et al. (2015) utilized this model to examine the effect of VR stress management program called (VR-DE-STRESS) on people with mood disorder. Hence, Neuman System Model supports this research on examining the effect of VR-Foot-ReST on users' relaxation and stress relief.

2.6.2 The Attentional Behavioural Cognitive (ABC) relaxation theory

The Attentional Behavioural Cognitive or ABC relaxation theory is another significant theory in this research. The theory established the idea that, the key to relaxation is sustaining Attention while diminishing overt Behaviour and covert or Cognitive activity (Smith, 2001, 2007b; Smith et al., 2000). The author added that relaxation involves sustaining passive focus and *letting go*, unlike our daily activities which involves actively striving. Relaxation endeavours evokes the fundamental process of healing and growth in which a person/people withdraw from the conventional daily stress and strive for healing and recovery, and opens back up to the world refreshed and restored (Smith, 1999a, 1999b; Smith & Joyce, 2004). The three phases of the ABC theory includes: (a) withdrawal, (b) recovery from fatigue, effort and tension as well as release from the constraints and burdens of adult, analytic, verbal thinking and ordinary everyday expectations; and (c) opening up to the world, renewed, and refreshed. This manifests in specific conscious experiences, relaxation/centering-related states of mind which the author termed relaxation-states (R-states).

Relaxation and stress management trainers use relatively passive approaches that are either (a) assisted or initially guided by an agent or external equipment (massage or biofeedback) or (b) unassisted forms of self-relaxation (Smith, 2007a), as is the case with this research to utilizes VR for relaxation and stress relief. Therefore, the ABC relaxation theory highlighted that different approaches to relaxation have different positive psychological effects and invokes one or several of the 12 R-states, categorized into four: (Basic Relaxation; Core Mindfulness; Positive Energy

Transcendence) and likewise have the potential to influence the users' stress states (Somatic Stress, Emotional Stress, and Cognitive Stress) (Barlow, Lehrer, Woolfolk, Sime, & Lehrer, 2007; Smith, 2007b, 2007a). Hence, this research utilized the ABC theory to examine the impact of VR-FRST application on relaxation and stress state dimensions.

2.6.3 Design Principles and Guidelines

Ni (2011) described design principles as fundamental, widely applicable, and enduring high-level guidance, which provides a benchmark for interaction design evaluation. The aforementioned author concurred that although there exist several user interface design principles, different people could explain them in different ways however; the underlying meaning remains the same.

For instance, Nielsen and colleagues proposed the ten usability heuristics for user interface design (Nielsen, 1994; Nielsen, Blatt, Bradford, & Brooks, 1994), Raskin highlights seven user interface design principles (Raskin, 2000), and Shneiderman and Plaisant (2004) presented eight golden rules for interface design. Generally speaking, all these aforementioned principles can in fact be applied to the design of any user interface.

The WIMP-based interfaces is an example of other more specific principles for a particular type of user interface, which plays the "unifying link" crucial role between different interaction techniques, making it possible to describe and design interaction techniques with coherent and consistent style. Utilizing desktop metaphors is a typical example of the widely adopted principle in WIMP user interfaces. The file folders metaphor is akin or similar to how people organize their file cabinet. The photo albums and music playlists in digital photo and music application, represents real-world music playlists and photo albums. Inculcating direct manipulations is also another important design principle for WIMP-based interfaces, which can be found, embedded in a majority of the desktop interaction techniques. Ni (2011) illustrated the drag-and-drop as an instance of direct manipulation to move around visual representations of objects like icons or controls. Several other interaction techniques were built upon the principle of direct manipulation, like a slider dragging to manipulate the parameters, resizing a window, clicking a button, colouring a cube in a drawing application, and so on. Consequently, in the fundamental design principle, direct manipulation has led to a wide range of coherent and consistent interaction techniques in the WIMP interfaces Ni (2011).

Shneidermand and Plaisant (2004) concurred that several researchers and interface designers over the years have documented design guidelines to record their insights over the years in an attempt to guide future designers. Ni (2011) explained that in contrasting from fundamental design principles, design guidelines are low-level, specific, practical, but sometimes difficult to implement or even wrong. These design guidelines are mostly about a specific aspect of a user interface design.

From the foot reflexology perspective, Sulaiman et al. (2016) outlined a multimodal interaction model for VR–FRST application as design guidelines as shown in Figure 2.9. Embedded within the multimodal interaction model are the design requirements, structural elements of TFR, feature composition and interaction entities. All of which contained detailed rubrics of each component. This interaction model contributed to the design and development of the integrated multimodal interaction framework for VR–FRST.

2.6.4 Information Architecture

In computer sciences, *Information* is considered to be the result of processing (Floridi, 2005). *Architecture* on the other hand, is considered to be the process of constructing or developing (i.e., planning, designing, and building) any structure (like a system, a road network, or even a building). 1975 saw the combination of both terms for the first time by Richard Wurman as *Information Architecture* (IA), which highlighted the necessity of representing data into meaningful information usable by people. There have been numerous definitions of IA over the years, which has brought a tremendous debate on the actual definition of IA. However, the Information-Architecture-Institute (2013), and Morville and Rosenfeld (2007) supports the researchers definition of IA to be the discipline of organizing and outlining the functionality and content of an application, which incorporates navigation schemes, labelling, search system, and application of design and interaction principles in the information system.

2.6.5 Multimodal Interaction Theory

Theoretically according to Dumas et al. (2009) as can be seen in Figure 2.5, the multimodal interaction between human and machine are of two (2) phases (human to machine) and (machine to human) both containing four distinctive states which includes:

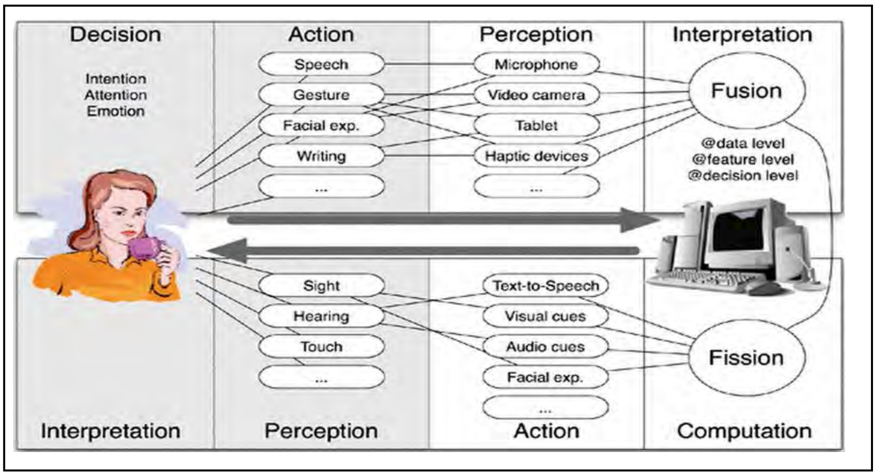


Figure 2.2. A representation of multimodal man-machine interaction loop (Dumas, Lalanne, & Oviatt, 2009)

Decision state
Action state
Perception state
Interpretation state

Human to Computer

Computational state

Action state
Perception state
Interpretation state

Computer to Human

USER – TO – MACHINE

Decision state is the first state when a human interacts with a machine in which the interaction message is prepared consciously for an intention or unconsciously for attentional content or emotions.

Action state is the second state where the selection of the interaction message is done, like gesture, body or head movement, speech, facial expression, etc.

Perception state is the third state where the machine makes use of several modules or multiple sensors or recognizers as Dumas et al. (2009) describe it, to capture as much information about the interaction as possible from the users' expression.

Interpretation state is the fourth stage where the multi modal system would try to give some meanings to the different information it collected in the perceptions state. At this particular stage, several interaction messages are combined in a process called "FUSION". The fusion engine is responsible for giving common interpretations to the collected inputs.

HUMAN – TO – VR SYSTEM

Okere (2015) presented the multimodal User - VR system interaction loop using Dumas et al. (2009) as a foundation. A graphical representation of the identified interactive features of the haptic, visual and aural modalities from both the patient's and practitioner's perspective, in a Man-to-VR system interaction loop, is presented represented in Figure 2.6.

Decision state is the first state when a patient interacts with the VR system in which the interaction message is prepared consciously for an intention or unconsciously for attentional content or emotions.

Action state is the second state where the selection of the interaction message is done, like gesture, body or head movement, speech, facial expression, etc.

Perception state is the third state where the VR system makes use of several modules or multiple sensors or recognizers as Dumas et al. (2009) describe it, to capture as much information about the interaction as possible from the users' expression.

Interpretation state is the fourth stage where the multimodal system makes sense and gives meanings to the different information it collected in the perceptions state. At this particular stage, several interaction messages are combined in a process called "FUSION". The fusion engine is responsible for giving common interpretations to the collected inputs.

MACHINE – TO – USER

Computation state is the first stage when the computer interacts with humans or the user, in which action is taken following the business logic and dialogue manager rules defined by the developer. This depends on the interpreted message extracted during the fusion and interpretation. An answer is the generated to answer the question asked of the machine. The fission engine, which is responsible for returning a message to the user through an adequate modality or a combination of modalities, will then determine the most relevant modality(s) to respond the interaction. This is then transmitted back to the action state and presented to the users through the several output methods available and chosen by the machine during the previous fission state. This interaction is then perceived by the user visually, aurally, haptically or so. This forms the basis of the development of the foot reflexology multimodal interaction model for VRST purpose.

2.6.6 Multiple Resource Theory (MRT)

Researchers have concurred that majority of the multimodal research is theoretically grounded in the predictions of the Multiple Resource Theory (Walvoord, Redden, Elliott, & Coovert, 2008; Wickens, 2002). The core system of belief of the MRT is that (i) people/users have several independent cognitive resources, (ii) some of these resources better lend themselves to simultaneous use, (iii) often times, tasks that require the use of varying resources can often be performed simultaneously, and finally (iv) when there is a competition for the utilization of the same modality, it can produce interference. That is to say, different cognitive resources exist to process information from different modalities like (visual, audio, or tactile information) (Walvoord et al., 2008; Wickens, 2002). This implies that, the presentation and representation of huge amount of information through the same modality tends to likely overwhelm or overload users' cognitive resources associated with that modality, while such information presented using multiple modalities is less likely to overload users' cognitive system needed to process the information (Walvoord et al., 2008; Wickens, 2002). Hence, this underlines the significance of representing large amounts of independent cognitive resources or information using multimodal interaction, particularly in high-workload contexts (Burke et al., 2006; Walvoord et al., 2008; Wickens, 2002). The following section presents integrated framework in Interaction research, the concept definition and evolution in the last few decades.

2.7 Integrated framework in Interaction Research

The term integrated is a popular buzz word in computing that refers to two or more components merged together into a single system, to form or blended together into a functioning or unified whole (Sedgley & Jackiw, 2002; TeamWork-Systems, 2018). Hence, relevant significant components that make up the multimodal interaction framework for virtual reality foot reflexology stress therapy are identified from relevant research and literature, and designed together into a single framework to form the integrated multimodal interaction framework for virtual reality stress therapy. The integration of architectures or frameworks for an enhanced performance can be seen in several researches like (Martini & Choo, 2012). Martini and Choo (2012) integrated two widely used digital forensics framework architectures of McKemmish (1999) and NIST (Kent et al., 2006) to propose an integrated conceptual digital forensic framework for cloud computation. Chen et al. (2017) also proposed an integrated framework for software defined networking, caching and computing. Previously, software-defined networking (SDN), information-centric networking (ICN), and cloud/fog computing architectures existed, or were managed, controlled and optimized separately, and according to the authors, resulted in suboptimal performance. Thereby, proposing the integrated framework for networking, caching and computing to enhance performance. Hence, by integrating several pieces of the framework components into a whole unified framework, offered enhanced performance compared to the architecture that previously existed.

Meanwhile, there is no standard definition of an interaction framework within the research community, best known to the researcher or a standard component of an interaction framework, and is therefore subject to the researchers' subjective definition based on his application domain and specific objective. However, Ni (2011) suggested that a framework is a structure that consists of several interrelated components; and from his perspective, comprised of input device, interaction techniques, and fundamental design principles, and practical design guidelines. Other researchers have underlined interactive entities, object and technology, context, interaction and communication and so on (Angkananon et al., 2013c, 2013b, 2013a, 2014; Jetter et al., 2012; Petrie & Bevan, 2009; Rukzio, Broll, & Wetzstein, 2008; Sung, Chang, Hou, & Chen, 2010; Vyas, Dix, & Nijholt, 2008).

Hence, the researcher's focus is on this particular domain (virtual reality foot reflexology stress therapy), and identifying the significant components that must be considered for the multimodal interaction framework for virtual reality foot reflexology stress therapy from relevant research and literature, and integrate them into the integrated multimodal interaction framework for virtual reality stress therapy.

Framework in computer science research according to Karam (2006) is a structure to guide system implementation, software programming or research and design activities. Researchers over the past three decades have discussed and proposed interaction frameworks from varying application domain, purpose, interaction and framework components. The work of Kopp et al. (2004) saw the development of a framework for analyzing iconic gestures and generating novel iconic gestures for embodied conversational agents in multimodal interfaces (Kopp et al., 2004). However, its applicability and generalizability to other application domains is questionable, especially to this research's domain. The work of Boussemart et al. (2004), also saw the development of a framework for bi-manual gestural interfaces in 3D visualization and manipulation in an immersive virtual environments, which was built around a virtual interface widget called 'pie-glass'. The pie-glass is an adaptation of the concepts of bi-manual interaction, see-through interface and the tool-glass widget (Bier et al., 1993). However, their research not only dealt with a particular application domain, but the pie-glass features are also quite limited. Thus, it is not applicable and generalizable to other domains as well. Latoschik developed a software framework for gesture detection and analysis (Latoschik, 2001), but it is an algorithmic framework rather than an interaction framework.

Karam proposed a theoretical framework to understand and guide the research and design of gesture-based interactions, which was structured around four high-level categories: gestures, enabling technology, system response (output), and application domain (Karam, 2006).

Angkananon and colleagues conducted a series of studies which developed a general interaction framework, an extension of the work of Dix (1994) and Gaines (1988), aiding the design of technology to enhance communication and improve interactions between people, technology and objects, especially in complex situations (Angkananon et al., 2013c, 2013a, 2013b, 2014). The aforementioned authors argued that most frameworks are incomplete as the reviews they conducted on interaction frameworks revealed that most frameworks concentrated on people-people communication and interaction, technology to enhance communication. Several frameworks address many interactions between humans and computers (Dix, Finlay, Abowd, & Beale, 2004; Sung et al., 2010), and miss out on some important interactions, like the interaction between people technology and real objects, or People-People interaction, People-Objects interaction, People – Technology interaction, People-Technology-People interaction, People-Technology – Objects interaction. Consequently, they proposed a technology enhanced interaction framework which is claimed to be complete as it addresses every missing and necessary component of other frameworks as shown in Table 4.2.

Table 2.2

The major component of Technology Enhanced Interaction Framework
(Angkananon et al., 2013c, 2013a, 2013b, 2014)

Main Component	**Main Component of Technology Enhanced Interaction Framework Role**	
	Sub-component	***Examples***
People	Role	speaker – audience (e.g. teacher – student ; owner – visitor), peer-peer
	Ability/disability	physical disability, sensory disability, language, culture, communication, Information Technology (IT)
Objects	Dimension	2 dimensional (2D), 3 dimensional (3D)
	Property	colour, shape, size
	Content	human readable (text, pictures, audio, video), machine readable (QR codes, AR tag, barcodes, RFID tag, NFC)
Interaction and Communication	People-People(P-P)	verbal communication (speak, listen, ask, answer), non-verbal (lip-read, smile, touch, sign, gesture, nod), deixis (refer)
	People-Objects(P-O)	control (touch, hold, move), information retrieval: knowledge (look, listen, read, remember colour, shape, size), meaning objects (understand)
	People-Technology (P-T)	control (hold, move, use compass, type, scan, take photo, press, swipe), information transmission and storage (send information, save, store, search online or offline document, retrieve)
	People-Technology-People(P-T-P)	Control (send SMS, MMS, email, show information, chat), information transmission and storage (send information, save, store, search, retrieve)
	People-Technology-Objects (P-T-O) Technology	control (point, move, hold, scan QR codes, scan AR tag, use camera, use compass), information transmission and storage (send information, save, store, search, retrieve)
Technology	Electronic (store information on technology)	Online, offline, content, non-content, mobile, non-mobile
	Non-electronic (store information in objects)	Content, non-content, mobile, non-mobile
	Interface	Website, mobile website
	Application or service	Mobile website, mobile application
	Cost	Hardware, software, staff
Time/Place	Place	Same place (SP), different place (DP)
	Time	Same time (ST), different time (DT)
Context	Location	Indoor/outdoor
	Weather condition	Rainy, cloudy, sunny, windy, hot, cold, dry, wet
	Signal type and quality	Broadband, GPS, 3G

Table 2.2 continued.

	Background Noise	Background music, crowded situation
Interaction Layer	Culture	Gesture, language
	Intentionality	Understand, purpose, benefit
	Knowledge	Facts, concepts, principle
	Action	Touch, move, type, swipe
	Expression	Whether the action is correct, accurate, prompt
	Physical	Colour, size, shape

Several researchers have highlighted the interaction between people and technology in interaction frameworks (Abowd & Beale, 1991; Dix, 1994; Jetter et al., 2012; Klink, 2006; Larson et al., 2003; Rukzio et al., 2008; Sung et al., 2010). A number of other researchers also proposed frameworks that highlighted technology mediated interaction between people (Dix, 1994; Jetter et al., 2012; Klink, 2006; Rukzio et al., 2008; Sung et al., 2010; Vyas et al., 2008), while the frameworks of Jetter et al. (2012) and Sung et al. (2010) highlighted technology to enhance interaction between people and objects. Some other researchers have underlined frameworks that highlighted direct communication in the same time and at the same place (Abowd & Beale, 1991; Dix, 1994; Foulger, 2004; Klink, 2006). In addition to that, Cook and Hussey (1995)'s Human Activity Assistive Technology Model (HAAT) underlined accessibility in the interaction. Sung et al. (2010) put forward a framework for the designing a mobile electronic guidebook for a history museum. A mobile electronic guidebook was designed for users' utilization in a history museum. Exhibits were made available to users using the electronic guidebook. However, there was no significant difference in the knowledge gained on the exhibits. The framework lacked the scenario where the exhibits are being properly presented or explained the expert. Bailey's Human Performance Model was modified in (Cook & Hussey,

1995) so as to accommodate assistive technology. They proposed a model whose components includes: human (abilities/skills), activity (determined by role), context (setting, social, cultural, physical), and assistive technology (hardware, software, non-electronic). Interaction design guidelines for accessibility, usability and user experience was extensively laid out in (Petrie & Bevan, 2009) (e.g., Web Content Accessibility Guidelines - WCAG 2.0 (WAI, 2008), Neilsen's usability heuristics, Shneiderman's 8 golden rules, W3C, and Research-Based Web Design and Usability Guidelines (U.S. Department of Health and Human Sciences, 2006) etc.) all of which refer to the interaction guidelines and principles between people and technologies, but do not take into consideration order forms of identified interaction.

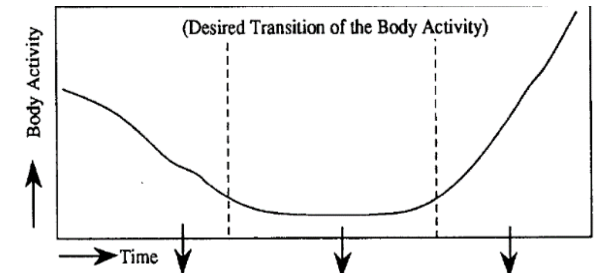
Sulaiman et al. (2018) also proposed a multimodal interaction model of traditional foot reflexology for implementation in virtual space by embedding the identified multimodalities, their degree of importance, and higher level design requirements to propose their model. This model however is from the patient to practitioner's (human-to-human) perspective. This model needs to be extended and transformed into a user-to-VR system perspective, and take into account the necessary VR interaction designs, design architecture and principles.

Angkananon and colleagues hence, underlined that most of the aforementioned authors and their proposed frameworks do not addresses all of the interactions like the interaction between people technology and real objects, or People-People interaction, People - Objects interaction, People – Technology interaction, People – Technology - People interaction, People – Technology – Objects interaction (Angkananon, Wald, & Gilbert, 2013c, 2013a, 2013b, 2014). All or part of which are significant interaction design components that must be considered, identified and integrated for the multimodal interaction framework for VR foot reflexology stress therapy application.

2.8 Virtual Reality and Stress Therapy

Virtual Reality Stress Therapy (VRST) application's or technologies are applications or technologies that permits users to enter, explore and interact with computer-generated environments with the use of the multi-sensory modalities such as sight, sound, and touch enabling them to combat stress (Awang et al, 2011; Gorini & Riva, 2008). One of the applications of VRST can be seen in the VR Relax-Refresh system applying virtual reality technology for body massage by Nakajima et al., (1994).

The VR Relax-Refresh system consist of a massage lounger that vibrates and massages (for body stimulation), a head mounted-display (HMD, for visual stimulation), a standard VCR (sound/aural stimulation), and an interface circuit that gears the massage chair and generates stereographic images. These three multi-



Stages / Stimulations	Sleep Encourage Stage	Sleep Stage	Refresh Stage
Visual Stimulation	Relaxing Images (mono)	Darkness	Refresh Images (stereo)
Aural Stimulation	Relaxing Music with body vibration	Quiet Music with Small Vibration	Loud Music
Body Stimulation	Soft Massage	None	Strong Massage

Figure 2.3. The experience story of the VR relax/refresh system

sensory modalities were put together by the designers to deliver body massage and sleep inducer via virtual space. By sitting on the lounger and putting on the head-mounted-display, the user goes through 3 stages this includes; the sleep-encourage stage, the sleep stage and the refresh stage as shown in Figure 2.3. Relieving the user of stress as the system puts the user to sleep with a varying degree of interaction and refreshing the user after some time duration.

Shah et al utilized VR to target Stress and depression in their VR mood induction procedure study (Shah et al., 2015). Participants who completed the program had significantly lowered subjective stress, depression, and anxiety; and increased skin temperature, perceived relaxation and knowledge. Jerdan et al. (2018) highlight that VR in stress and depression domain is currently at infancy as there is a lack of studies surrounding this particular domain, underlining the literature gaps that still exist. Hence, recommending future research to explore it further.

Another successful domain in which VR has been applied in health care as can be seen in the treatment of phobia through exposure therapy (VRET – Virtual Reality Exposure Therapy) and other domains of therapy and rehabilitation (Brinkman, 2012; Cukor et al., 2015; Hooplot, 2005; Morina et al., 2015b; Opriş et al., 2012; Parsons, 2015; Patterson & Nanni, 2015; Peperkorn et al., 2015; Rizzo, Schultheis, Kerns, & Mateer, 2004; Rizzo & Kim, 2005).

Strickland et al. (1997) explained that in these stimuli in VRET are usually generated as a result of the patients strong, irrational fear for a certain condition or situation such as fear of heights, fear of flying, agoraphobia, fear of spider, fear of driving, fear of public speaking and so on. These stimuli were traditionally generated by in vivo exposure, which involves presenting the patient with an actual physical stimulus or by having the patient imagine the stimulus in imagino therapy (Bruce & Regenbrecht, 2009). VRET allows another option of this exposure therapy, which can be safer, less embarrassing and a lot more effective as compared to the realism of in imagino therapy and In vivo. In simulating the multimodal interactivity virtually, allows the extra advantage of interactively regulating the induced anxiety in adjusting the parameters of the virtual environment by increasing or decreasing the fear factor to match the users' level of tolerance. The sense of immersion or presence is relatively essential in this form of therapy as it intensifies the patient's phobic responses as concurred by the studies reviewed and reported by Strickland et al (1997), which indicated that VR scenes can produce a variety of phobic symptoms, and the incorporation of sound and touch such as a furry spider greatly intensified the experience.

Music therapy and guided image therapy are two applications where the aural and visual modality are utilized to produce positive stimulus to patients/users, inducing relaxation, pain relief, anxiety and stress relief (Awang et al., 2011; Barrera et al., 2002; Buchanan, 2013; Daniel, 2016; Tam et al., 2016). The Bonny method of Guided Imagery and Music (GIM) has been used in the inpatient psychiatric setting, in the treatment of patients with post-traumatic stress disorder (PTSD) (Awang et al., 2011; Cukor et al., 2015; Patterson & Nanni, 2015; Albert Rizzo et al., 2015; Burns, 2001; Bruscia, 2010; Chou & Lin, 2006; Grocke, 2005; Lin et al., 2010; Beebe & Wyatt, 2009). This method allows access to the patients'/users' subconscious feelings, images, and memories and fosters empowerment and reconnection through self-understanding and an alliance with the therapist. These two modalities have been the two main modalities that have been utilized the most in stress therapy, which emphasizes their significant contribution to the domain. Only very few studies have highlighted the contribution of haptic modality to stress therapy. This research in turn, contributed to the body of knowledge, by highlighting the role and significance of haptic interaction to stress therapy.

There are many other ways people utilize to cope with stress. Some of the most effective methods are progressive relaxation techniques, biofeedback methods, physical exercise, rest or sleep, meditation or deep breathing, body massage, and *reflexology*; which is the main focus of this research.

2.9 Stress Relief and Relaxation

Generally, stress is cited and regarded as the second most frequent health problem afflicting individuals' health and well-being, and dubbed the "Health Epidemic of the 21st Century", estimated to cost American businesses up to USD300 billion per annum (Fink, 2016; World-Health-Organization[WHO], 2005). Stress is the physiological response to any demand perceived to be threatening to the physical, emotional or psychological well-being of a person (Varvogli & Darviri, 2011). Low to moderate levels of stress can be useful to a person, but high and persistent levels of stress become unhealthy, thereby causing more harm than good (Wilson, 2009). This drops the mental and physical well-being of the person and is a major factor of issues such as; hypertension, insomnia, onset of malignancy, depression, digestive disorders, diabetes, herpes, lead from various problems like irritability, quickness to anger, lack of concentration, decrease in mental and physical activity, eye fatigue, stiff shoulders, drowsiness, neck ache, back ache, discursiveness and lack proper judgment (Nakajima et al., 1994; Bagheri-Nesami et al., 2014).

Pressure (daily demands of life from work, family and society); frustration (dissatisfaction and insecurity from unresolved or unfulfilled issues) and conflicts (the existence of multiple incompatible needs or demands) are the most common sources of stress. In challenging situations when a person is experiencing stress, the brain prepares the body for defence "The fight or flight response" through the release of stress hormones (cortisone and adrenaline) which raises the blood pressure and prepares the body to respond to the situation (Grewal & Shekar, 2008; Sahai, 1996), with a good defensive response, the stress hormones in the blood are used to up reducing the effect of stress and anxiety symptoms as shown in Figure 2.4. But with a poor defensive response, when the body fails to counter the challenging situation, the hormones and chemicals remain unreleased in the bloodstream for a long period of time, which ends up resulting to stress-related physical symptoms like unfocused anxiety, dizziness, rapid heartbeats, tensed muscles (Life Positive Foundation, 2012).

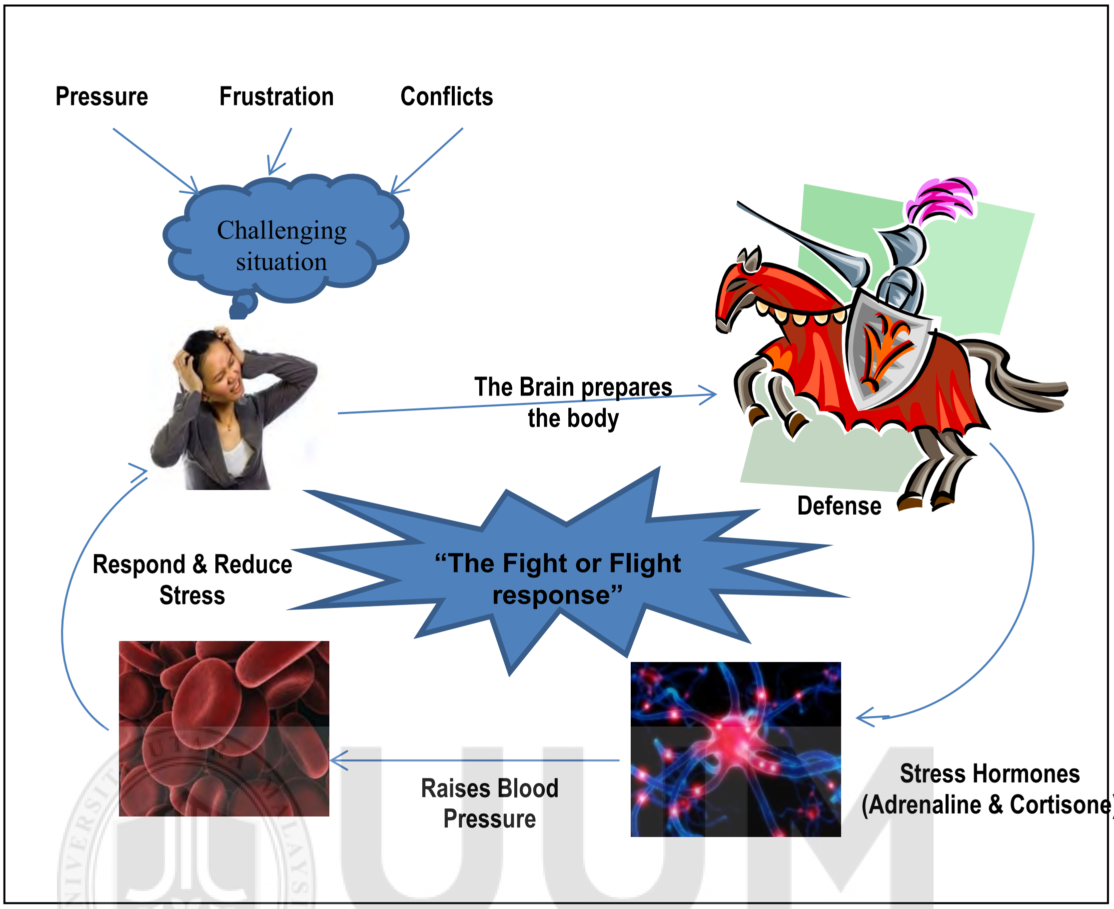


Figure 2.4. How the body gets stressed (Life Positive Foundation, 2012).

The stress response is activated by the sympathetic nervous system, and reflexology initiates the parasympathetic nervous system which is concerned with recuperation, stress relief and relaxation, allowing the body to attain the state of "Homeostasis", and reducing the body from the likelihood of stress related health issues (Song & Song, 2005).

2.9.1 Measuring Relaxation and Stress relief

There are a number of techniques to perform brain activity measurement which is determined by a number of factors according to (Dharmawan, 2007; Honal & Schultz, 2005). There are varying approaches to measure different phenomena: this range from direct measure such as detecting electrical currents or magnetic fields to indirect measures such as measure measuring metabolism or blood flow.

i. Invasiveness – the lesser the invasive nature of a procedure, the more feasible or practical the measurement technique is. When a procedure involves drilling or inserting equipment into the brain, it makes that procedure invasive in nature.
ii. Spatial resolution – spatial resolution is the measure of how closely lines can be resolved in a measurement. In order to examine details of the brain, a proper spatial resolution is required.
iii. Time resolution – it is also referred to as temporal resolution. This describes the amount of detail in a measurement by the number of samples (or image resolution for brain imaging technology) delivered over a given period of time.
iv. Cost – the resources required to carry out a measurement procedure are also taken into consideration. This implies the cost of the measurement procedure. Dharmawan (2007) highlighted that the choice of selecting a device continuously and over a long period of time depends on how much resources it covers.
v. Applicability as portable device
vi. Dharmawan (2007) included this factor to also be taken into account. The handiness and easy mobility of the measurement is required for certain researches.

2.9.1.1 EEG & Related Techniques for Relaxation and Stress Relief Evaluation

EEG is the acronym for Electroencephalogram, which is the electric potential recorded at the scalp surface from the electrical activity of large ensembles of neurons in the brain. A rhythmic activity which is a-periodic and unpredictable activity is constantly present in the brain. This is a result of the total activity being generated by all the neurons in the brain. The frequency range is divided into different bands: Delta (0.1 – 3.5Hz), Theta (4 – 7.5Hz), Alpha (8 – 13Hz), Beta (14 – 30Hz), and Gamma (>30Hz) as shown in the figure below.

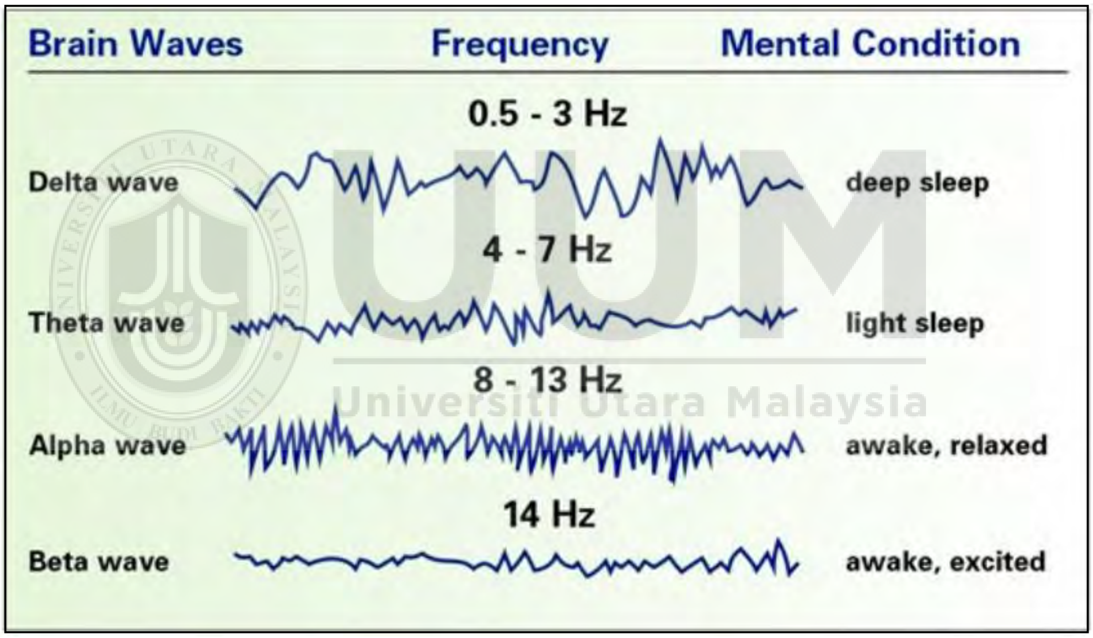


Figure 2.5. An Overview of the categorization of brain waves (Dharmawan, 2007; Wessel, 2006)

Dharmawan (2007) and Wessel (2006) examined and presented several brain activity measurement techniques asides *EEG (Electroencephalogram)* based on literature and practice from accessible facilities. Amongst these methods includes *ECoG* (*Electrocorticography), PET* (*Position Emission Tomography), MEG* (*Megneto *encephalography), fMRI (functional Magnetic Resonance), NIR (Near-infrared light)* each with its own strengths and downsides.

i. *ECoG,* Electrocorticography is a form of invasive EEG where electrodes are connected directly on the brain. This technique possess both high temporal and spatial resolution (Dharmawan, 2007). Being that the procedure is invasive in nature, it requires surgical operation and surgery is expensive to conduct not to mention the significant safety risks that come with it (Dharmawan, 2007; Wessel, 2006).

ii. *PET,* Position Emission Tomography is used to examine metabolism on a cellular level through the tracking of injected radioactive isotopes. This is built upon a foundation that there exist a higher level of metabolism in areas of increased activity and more isotopes are supplied by the blood flow. With this knowledge in hand, areas that are generating activity can be determined. This measurement technique posses a good temporal resolution as its merits but with a really bad temporal resolution of about 2mins as its demerits. Plus the risk of radiation which makes the method relatively dangerous to the human body.

iii. *MEG,* Magneto encephalography is used to measure the cortical magnetic field which is produced by electrical currents. Some of the advantages of this method are that it is non-invasive; possess good temporal and spatial resolution. Nonetheless, the cost of acquiring the equipment is highly expensive. And Wessel (2006) added that the real-time properties for analysis are poor.

iv. *MRI,* Magnetic Resonance Imaging is used to pass radio waves through a large magnetic field. A computer then observes the radio waves variations as a result of electro-magnetic activities in the brain to generate a picture.

v. *fMRI,* Functional Magnetic Resonance Imaging is used to provide information on brain metabolism using Blood Oxygen Level Dependency (BOLD). Some of the advantages of this method are that it possesses good spatial resolution and it is non-evasive. However, it possesses a poor temporal resolution, plus the cost of procuring the equipment is highly expensive.

vi. *fNIR,* Functional Near-infrared light is used to penetrate the human head to an enough depths where functional mappings of the cerebral cortex can be done. This method possess a good temporal resolution, but is not feasible yet as reported by Dharmawan (2007).

vii. *CT,* Computer Tomography utilizes a special X-ray device to collect image data from varying angles around the human body, and then computer processing of the information to show a cross-section of body tissues and organs. This method can be used to show numerous sorts of tissues, soft tissues, bones, and blood vessels. However, produces only anatomic data.

The Table 2.2 shows the setbacks of the other alternative methods discussed above. In other to select the best brain measurement method to evaluate the effectiveness of VR-FRST for relaxation and stress relief, the method has to possess a high spatial and temporal resolution, be cheap, portable, and be non-invasive. However this method is at the moment non-existent as also seconded by Wessel (2006).

Table 2.3

Comparison of Brain Activity Measurement Methods

Methods	Disadvantage
ECoG	Requires surgery, highly invasive procedure
MEG	Very expensive, poor real-time properties for analysis
CT	Provides only anatomic data
PET	Risk of radiation and possess poor temporal resolution
MRI	Provides only anatomic data
fMRI	Very expensive and possess a poor temporal resolution
fNIR	Still under research

That being said, EEG is most commonly used method to measure brain activity especially in the domain of virtual reality, foot reflexology, relaxation, stress relief, and other related domains (Bai & Li Qiu, 2007; Bhattacharya & Petsche, 2005; Chang & Lo, 2005; Hebert, Lehmann, Tan, Travis, & Arenander, 2005; Joseph, Kannathal, & Acharya, 2007; Kannathal, Choo, Acharya, & Sadasivan, 2005; Kiymik, Akin, & Subasi, 2004; Kobayashi et al., 1999; Lee, Kim, Kim, Suk Park, & Kim, 2004; Lin et al., 2006; Lin, Chiu, & Hsu, 2005; Lu, Wang, & Yu, 2006; Patil & Bormane, 2006; Song, Lee, & Kim, 2004). Asides from this, despite EEG offers a not so great spatial resolution, it offers an excellent temporal resolution, a direct functional correlation of brain activity, it is non-invasive, cheap to acquire, and portable to use and does not require high level of expertise to apply as compared to the other methods.

The Alpha signal depicts the relaxation of to be within the range of 8 – 13Hz to confirm the effectiveness of the multimodal virtual reality foot reflexology stress therapy application for relaxation and stress relief. This therefore answerer the last and final research question of this study.

2.9.1.2 SRSI 3 for Relaxation and Stress Relief Evaluation

Smith highlighted that different approaches to relaxation have different positive psychological effects and invokes one or several of the 12 relaxation states (also known as the R-State), which were categorized into four (Barlow et al., 2007; Smith, 2007b, 2007a): Basic Relaxation; Core Mindfulness; Positive Energy Transcendence. These approaches to relaxation and stress relief likewise have the potential to influence the users' stress states (Somatic Stress, Emotional Stress, and Cognitive Stress).

i. Basic relaxation: These are experiences that usually manifest in causal relaxation activities. Basic relaxation can be experienced as reduction in tension, fatigue, or distress. It is the absence of a negative. Basic Relaxation correspond to the following R-states:

   a. Mentally relaxed (at ease / peace)
   b. Physically relaxed
   c. Disengaged (faraway / indifferent)
   d. Sleepy
   e. Rested / refreshed.

ii. Mindfulness: This R-state category is generally defined by three variables: awareness and focused attention, absence of elaborative thought, and nonjudgmental acceptance as concurred by (Baer, Smith, Hopkins, Krietemeyer, & Toney, 2006). Mindfulness corresponds to the following R-states:

a. Quiet
b. Aware / Focused / Clear
c. Accepting
d. Innocent
e. Centering
f. Awakening

iii. Positive energy: This particular R-state is primarily defined by joyfulness and optimism. Studies have shown that by joyfulness and optimism is associated with increased health and, immune system functioning, and longetivity (Pressman & Cohen, 2005). Hence, positive energy corresponds to the following R-States:

a. Joyful (Happy)
b. Optimistic
c. Energized
d. Thankful and Loving

iv. Transcendence: This R-state category reflects a radical reduction in self-referent thinking. In other words, they reflect intense selflessness where one is concerned by something greater than one's self (Smith, 2007a). Transcendence corresponds to the following R-States:

a. Awe and wonder
b. Prayerful / reverent,
c. Mystery (feeling a deep mystery of things beyond ones understanding),
d. Timeless / boundless / infinite / at one

All of these states can exist alone or in combination with other states (Smith, 2007a). Several studies have utilized the ABC relaxation theory to explore the process of relaxation across various relaxation strategies (Godse, Shejwal, & Godse, 2015). This study also utilized the ABC relaxation theory to access the effect of VR-FRST application on users' relaxation and stress relief. Amutio and colleagues examined the impact of mindfulness-based stress reduction (MBSR) program on improving well-being (i.e. relaxation states and related positive emotions) in a longitudinal study for a period of one year (Amutio, Martínez-Taboada, Hermosilla, & Delgado, 2015). In another study by Smith and Joyce (2004) conducted a comparative study to investigate R-States and stress symptom-patterns associated with listening to Mozart versus New Age music. Findings revealed that Mozart listeners reported low levels of negative emotions, higher levels of psychological relaxation than those of new age listeners or reading popular recreational magazines.

Hence the smith relaxation stat inventory III (SRSI 3) not only evaluates for relaxation levels or states, it also distinguishes the exact nature of these relaxation states users perceive. The SRSI3 also evaluates for users' stress states, making this evaluation technique perfect for this research, as the ultimate goal is to propose VR-FRST application technique effective for both relaxation and stress relief. The following section presents foot reflexology, its history, theory, practice, and varying existing applications of foot reflexology.

2.9.2 Foot Reflexology – History, Theory, and Practice

Literatures have revealed that reflexology is not a new therapy with countless evidences to imply its effectiveness and use right from the early Egyptians, Chinese and Northern American Indian tribes for the purpose of healing (Shaw, 1987) even though that may not have been the name it was called. The modern history of reflexology started early in the 20th century by a US specialist, Dr. William Fitzgerald and his team who observed that applying pressure to certain areas of the hands and feet resulted in an anaesthetizing effect on the corresponding body area (Botting, 1997; Sahai, 1996). Eunice D. Ingham, a physiotherapist, who was also a member of the team built further on this and went many steps ahead, and further developed the work into what is considered the "modern day reflexology". She argued that if hard pressure stops pain sensation being transmitted to the brain, reduced pressure might stimulate the nerve impulses, attaining therapeutic effects beyond pain reduction. While working on the hands, she discovered that there are also reflex points located on the feet and that working with them was more effective (Sahai, 1996).

2.9.2.1 Benefits of Reflexology

Foot reflexology as was mentioned earlier is a form of foot massage that targets certain reflex points (reflections of body parts) on a person's foot and applies pressure to it, corresponding to a map of other parts of the person's body. This in turn helps open the blocked energy pathways, improves blood circulation, encourages healing, and improves the functioning of the internal organs for the purpose of health improvement (Himmelstoss et al., 2007; Samuel & Ebenezer, 2013; Stephenson, Weinrich, & Tavakoli, 2000; Tiran & Chummun, 2005). Foot reflexology has been widely used to improve quality of life and well-being, reflected in numerous benefits such as stress relief, distress, insomnia relief, potential diagnostic tool, sleeping disorder and as a complementary treatment tool which has been tested and proven effective in countless studies (Abbaszadeh et al., 2018; Bakir et al., 2018; Choi & Lee, 2015; Ebadi et al., 2015; Hudson et al., 2015; Meghashri, 2018; Sahbaee et al., 2015; Samuel & Ebenezer, 2013; Shahsavari et al., 2017; Stephenson et al., 2003; Stephenson et al., 2000; Véron et al., 2012; Yılar Erkek & Aktas, 2018).

Sahbaee et al. (2015) conducted a study to examine the effect of foot Reflexology therapy on pain of scoliosis patients undergoing spinal surgery and results revealed that foot reflexology massage, as one of the branches of the complementary alternative method, can be recommended in patients after spinal surgery to reduce pain.

Choi and Lee (2015) conducted a study to identify the effects of foot reflexology massage on fatigue, stress, and depression of postpartum women, and the results show that the foot reflexology massage is an effective nursing intervention to relieve fatigue, stress, and depression for postpartum women.

Hudson et al. (2015) conducted a study to examine the effect reflexology on pain, anxiety and satisfaction during minimally invasive surgery under local anaesthetic. Their study findings revealed that, patients that receive reflexology prior to undergoing varicose vein surgery reported significantly lower intraoperative anxiety and shorter pain duration than participants receiving treatment as usual.

The benefits of reflexology cannot be over emphasized. It was recommended by Evans (1990) and (Tiran, 1996) in midwifery for the treatment of some of the problems faced by women in the postnatal period and for mothers with severe headaches, stiff necks, back and shoulders as a result of an adverse reaction to the epidural anaesthetic in labour. Improvements in patients with multiple sclerosis were noticed by Ashkenazi (1993) as a result of reflexology which included an improvement in motor ability, mental status, bowel and sexual functioning alongside decrement in pain. The diagram in Figure 2.9 shows the map reflexology zones of the feet corresponding to various parts and organs of the body (Hazel Barnes, 2009).

Atkin and Harris (2008) conducted a study to investigate if reflexology could help manage stress in the workplace and found out that there are some trends towards improvement in perceived health and well-being following reflexology intervention. These findings are also supported by Johns et al.'s (2010) research findings whereby the test participants revealed that the most instantaneous benefit of reflexology is relaxation. Aside stress relief, reflexology has also got positive influence towards significant decrement in anxiety among those patients with severe infirmity like cancer (Stephenson et al., 2000; Mc Vicar et al., 2007) and patients with rheumatoid arthritis (Khan, Otter, & Springett, 2006).

Reflexology can also be used to break stress patterns and toxins located in the body. In other words, through the application of pressure on the reflex point of a target organ, generates a signal that travels through the peripheral nervous system, after which it goes into the central nervous system where the necessary processing is done at various parts of the brain. This is then transmitted to the internal organs to allocate the needed adjustments in fuel and oxygen, then a response is generated, which is passed on to the motoric system. This ends up, adjusting the body's overall tension level (Himmelstoss et al., 2007).

According to Sahai (1996), the reflexologist systematically exerts firm pressure on the reflex points of the patient's feet. This pressure is gently and carefully exerted so as not to miss any point by making small caterpillar like creeping movements with a thumb, finger or a reflexology stick along each foot, stimulating and sending nerve impulses along the energy pathways to the part of the body they are connected to as shown in Figure 2.9.

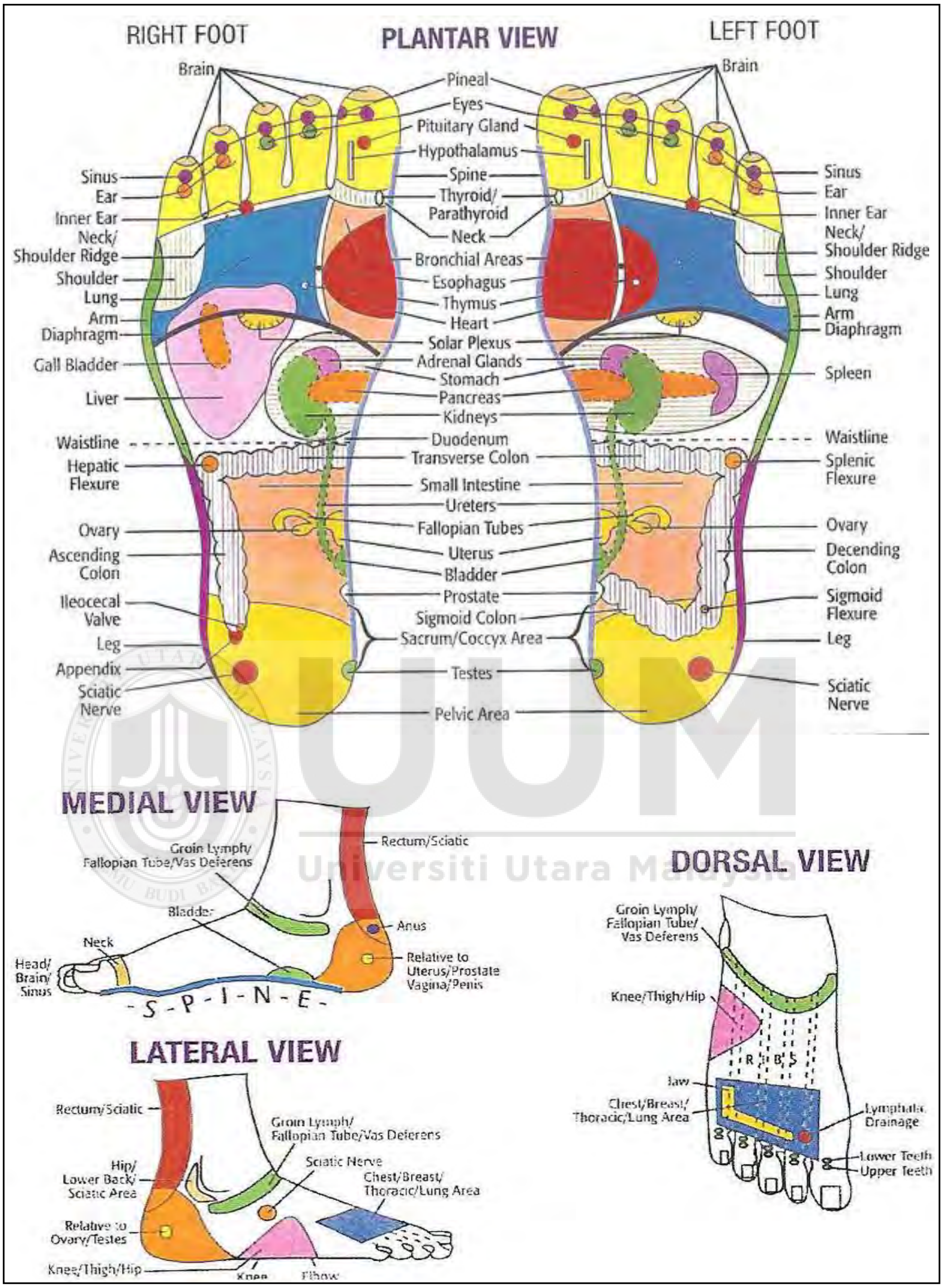


Figure 2.6. Reflexology zones of the feet corresponding to body areas (Hazel Barnes, 2009).

This therapy is safe, natural and with no side effect, but patients reacting to the treatment are not uncommon. In such cases, the patients are only experiencing a cleansing process or a healing crisis as Sahai (1996) would have it. This indicates that the body now has the capacity to deal with its toxic or toxin issues that might have been lying dormant in the body. These healing crisis symptoms usually differ according to the nature of toxins released into the blood stream. That is, symptoms affecting the respiratory system come in the form of a flu or common cold, symptoms affecting the digestive system could come in the form of nausea, diarrhoea, vomiting or increase in the patient's urination this time with a darker and stronger smell due to the toxins being washed out (Sahai, 1996). Reflexology therapists usually do not venture into areas beyond their expertise. In that, they do not prescribe nor diagnose nor promise a cure. They rather during conversation usually explain what the therapy is all about and how it works, encourage patients to relax and open up, and advise the patients to seek professional medical attention if/when any severe symptom is observed (Sahai, 1996).

Not only that it has no side effects, the therapy is completely for everyone, even infants, except in some exceptional cases whereby the reflexologist have to exhibit extreme caution or postpone treatment. The most common one's are when the patients feet is damaged or has an injury like boils, cuts, bruises, damaged ligaments or tendons, fractures, or for women experiencing their menstrual circle or after an operation by the patient since reflexology improves blood circulation, it could lead to an increase in bleeding from the wound as well quicker elimination of the drugs therefore destabilizing the reason for which it was administered, and in the same manner, patients suffering from fever are also advised not to undergo reflexology until they are fever-free as the body is already in a state of battle with the invasion of toxins and, therefore, would not be wise to worsen the situation by emitting more toxins into the blood stream (Sahai, 1996).

The reputation and benefits of reflexology have motivated researchers to automate the practice. This can be seen from the works of Himmelstoss et al. (2007) on the development of electro foot reflexology stimulator. This device was designed on the basis of foot reflexology massage and electro-acupuncture. The stimulator has potentials in assisting further research in establishing new alternative medical techniques.

2.9.2.2 To Treat or Not To Treat

Not all patients are recommended to receive reflexology therapy. Therefore, the practitioner must first determine whether or not the patient would benefit from the therapy. Certain health or medical conditions require proper care and precautious handling by the reflexologists (Hope-Spencer, 1999; Ingham, 1984; Ministry-of-Health-Malaysia, 2011). Such conditions like early pregnancy, cardiovascular disorders, oedema, diabetes, recent surgery, arthritis, bleeding disorders or on anticoagulant therapy, where there is a tendency for easy bruising/bleeding, cancer as it may aggravate the spread of cancer cells. However, there certain conditions where reflexology should not be performed on the patient, which include: localized skin diseases, inflammation or swelling of the massage area (feet, hand and ear), as pressure exertion and movement during treatment may aggravate the condition.

i. Pregnancy particularly during the first trimester, as this may lead to unfortunate miscarriages.
ii. Diarrhoea and vomiting patients should also avoid treatment as this may over stimulate the body and aggravate the situation further.
iii. Patients experiencing fever or any infectious diseases should also avoid treatment, as this may also over-stimulate the already stressed body system trying to combat the infection.
iv. Patients experiencing a continuing extreme negative reaction to reflexology are advised against taking further treatment.
v. Thrombosis and thrombophlebitis patients are also advised against reflexology as it may trigger blood clots lodging in or near the heart.

2.9.2.3 Reflexology Artifacts and Electronic Massage Devices

The importance and benefits of foot reflexology therapy have long been exploited to improve health. Currently, it is widely adopted as a complementary therapy, for recreation, relaxation and stress relief, as well as a potential diagnostic tool. Nowadays in our society, Reflexology Artifacts (RA) or electronic foot massage devices that claim to be alternative substitutes for the traditional foot reflexology practice (Okere et al., 2015), can be found existing in recreational parks, or some outdoor/indoors centres as seen in Table 2.3 and Table 2.4. These artifacts attempt to replicate the haptic interaction similar to that practiced traditionally. A study examined RA and compared it to traditional practice, and found that RA as an alternative is somewhat effective and successful for the purpose of its design and can be used as an alternative in the absence of TFR. However, it is challenged by conspicuous limitations that result from the absence of the other modal components (visual and aural elements) of the traditional therapy and required know-how (Okere et al., 2015). Hence, proposed the incorporation of VR to address these challenges.

Foot reflexology is generally a pain related therapy. The degree of pain has to reach an optimal level, painful enough at each reflex point to get the job done but also bearable enough to be pleasurable. Inferably, the amount of pressure exerted by these artifacts determines the degree of pain experienced by the patient/user. Consequently in the context of this research, a selected RA or electronic foot massage device is incorporated to the prototype as the haptic component in multimodal interaction of the VR foot reflexology stress therapy.

Table 2.4

Selected Reflexology Artifacts

Non-electronic	**Electronic**
 **Reflexology Slipper**	 **Electro-Reflexologist Device**
 **Reflexology Pebbles**	 **Reflexology-foot-massager**
 **Reflexology Mat**	 **Apna Elctro-Reflexology Massage Slippers**

Table 2.5

Electronic Massage Devices for stress relief

No	Source	Device	Focus of study
1.	Himmelstoss et al., (2007)	Foot Reflexology Stimulator	Developed an electric foot reflexology stimulator on the basis of foot reflexology massage and electro-acupuncture by passing electric DC- currents and low-frequency AC-currents.
2.	Modern-Reflexology, (2016)	FootSmart Acu-Point Therapy Foot Massager	This amazing foot massage machine has four air filled bags above the foot. This will increase the compression level and can apply pressure to your foot pressure points. This machine consists of total 192 acupuncture nodes, which helps to stimulate your body and to keep you healthy.
3.	Modern-Reflexology, (2016)	Irest foot and Calf Reflexology Massager	A very powerful machine to relax your ankles and foot. It provides great relief to your foot and calf muscles, so that you can have a peaceful treatment of legs. Energize the tired legs and feet, will recover your foot and calf muscles, activate foot pressure points and get rid of tension. It possesses a powerful vibration can penetrate your muscles deeply.
4.	Modern-Reflexology, (2016)	A SPT AB-762R Reflexology Foot Massager	This foot massage machine is known for its elegant design and amazing foot massage. The vibrating plate will stimulate your foot pressure points and will give your body a great relief. It also stimulates the blood circulation and relieves tension.
5.	Modern-Reflexology, (2016)	ProReflexology Foot Massage Machines	Very popular design and model, relaxes your foot muscles instantly with 3 different speeds to set the intensity. It has an auto shutdown function after 5 minutes of idle time 3 dimensional professional massage experiences. Rolling motion experience. It is quite and powerful.
6.	Geezone. (2008).	Chi Machine Deluxe with infrared foot massager	Simply lie down and relax, with your feet on the padded ankle rests or sitting down on a chair and placing the feet onto the massage platform containing 6 infrared heating lamps which warm up within the first few minutes of operation. The body responds to the movement of your feet as the exerciser swings them gently and rhythmically from side to side. It is said that when used for a duration of15mins/day properly exercises the users muscles while achieving a relaxing massage that will leave you feeling refreshed for the rest of the day
7.	Modern-Reflexology, (2016)	Deluxe Massage Wonder 8000A Reflexology Rolling Foot Massager	A very popular foot massage machine to get fast relief from stressed foot muscles. This machine can provide you great relaxation to your muscles. It comes with a 3 way speed setting mode, where you can set the low, medium, high speeds with 15 minutes massage intervals.

2.10 Recent Advancement for Virtual Reality and FRST

With respect to this research, the final outcome is the presentation of an integrated multimodal interaction framework and VR-Foot-ReST prototype that interacts haptically, visually and aurally with users for stress therapy. The framework development is the next phase of this research. The study of (Okere, Sulaiman, Awang, & Foong, 2014; Okere, Sulaiman, & Foong, 2013) was the first attempt into the exploration of the prospect of traditional foot reflexology therapy in a virtual space, and probed the existence of multimodality in the therapy that leads to relaxation and stress relief perceived by the patients. The study confirmed the

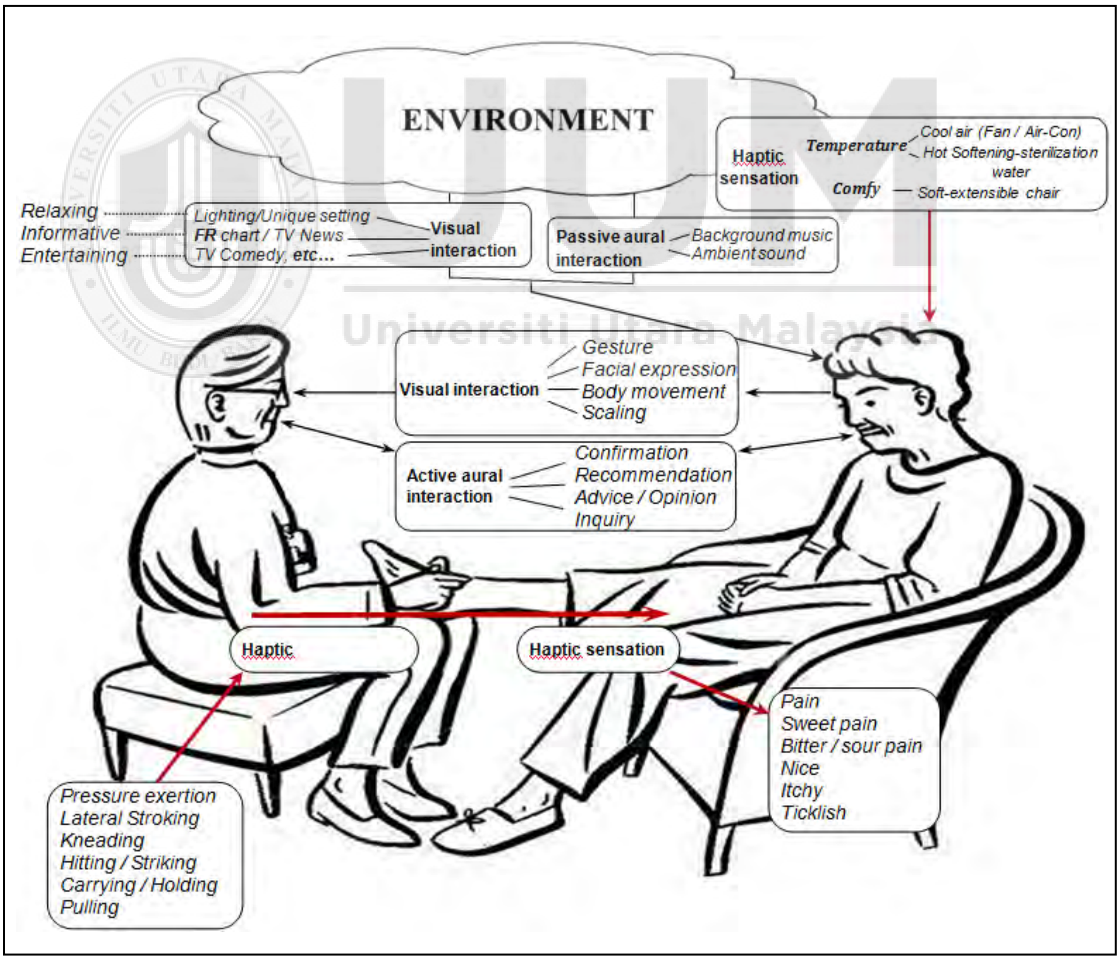


Figure 2.7. Graphical representation of the Human to Human multimodal interactivity in foot reflexology (Okere, 2015; Suziah Sulaiman et al., 2018)

existence of the 3 key modalities in therapy (aural, visual and haptic interactivities). Subsequently, the composing features of the multimodal interactions were further identified and summarized in a graphical representation as shown in Figure 2.7.

The researchers went ahead to explore the hierarchy of importance and degree of significance of the contributing modalities in the therapy using the Analytical Hierarchical Process (AHP) (Chimeremeze, Sulaiman, Rambli, & Foong, 2014). They employed AHP to determine the hierarchy of importance of each contributing modality or interactive element, and the study findings as presented in Figure 2.8 revealed that all the modalities played significant role in the relaxation and stress relief patients experienced, and that haptic/touch modality or interactive element possessed the highest hierarchical significance, accompanied by visual then finally aural interactivity (Chimeremeze, Sulaiman, Rambli, et al., 2014).

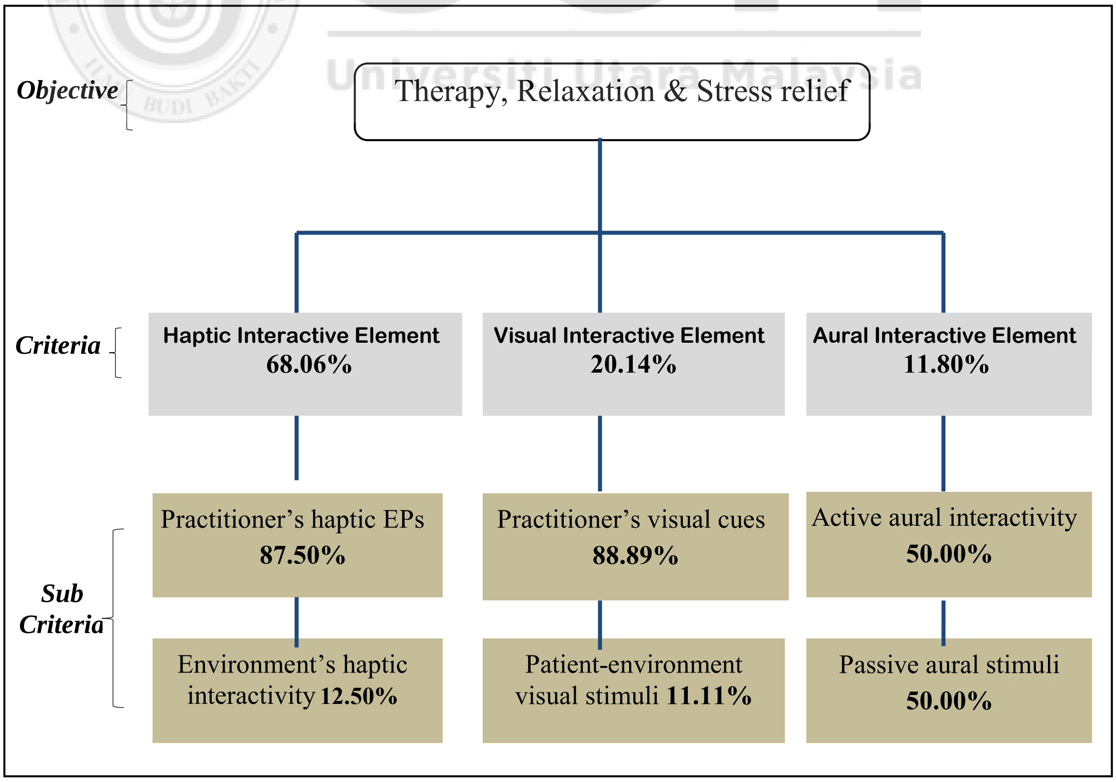


Figure 2.8. The degree of importance of the multi-modal elements in TFR

In addition to that, being the first documented attempt at the identification and classification of the multimodal interactive nature of foot reflexology, Okere, Sulaiman, Rambli, and Foong (2016) proposed a higher level of design requirements from the patients'/users' perspectives explored and presented in the multimodal interaction design guidelines for VR foot reflexology therapy application.

Sulaiman et al. (2018) further proposed a multimodal interaction model of TFR for implementation in virtual space by embedding the identified multimodalities, their degree of importance, and higher level design requirements to propose the model. This model was subsequently reviewed by experts, and the feedbacks from these experts were utilized to reconfigure the final interaction model as presented in Figure 2.9. To further underline the potential benefit VR may offer the therapy, Okere et al. (2015) compared the traditional reflexology therapy with the current existing alternative application of the therapy (Reflexology Artifacts – RA), and revealed that RA posses some advantages and also challenged by conspicuous limitations, hence proposed VR as a suitable alternative to effectively address these challenges. From the study, users that undergo the therapy using reflexology artifacts expressed considerable strengths which include accessibility (easy access to these artifacts), time and cost saving, over its counterpart the traditional Foot Reflexology practice. It was also reveal that there are conspicuous limitations that is associated with undergoing the therapy using reflexology artifacts. This includes the lack of required know-how to effectively use the artifacts (experts also expressed this to be a challenge as these artifacts when used wrongly may cause more harm than good), pressure regulation (practitioners are usually able to gauge patients pain threshold to use in exerting appropriate amount of pressure compare to the fixed pressure that is exerted by reflexology artifacts), sensation variety (TFR therapy is usually accompanied by a range of sensation variety which is lacking in RA), multimodal environment (users often interact multimodally in the traditional therapy visually, aurally, and haptically, whereas RA is a unimodal/haptic only interaction), lack of presence/"being there" (in TFR patients are actually there and present for the therapy which is both soothing and relaxing, whereas RA users lack that presence / sense of being there). All these underlined the potential of VR technology in the foot reflexology therapy, as it can exploit the combined strength of RA and TFR. However, the application of the therapy in a virtual space required further investigation and the development of a proper framework, which was lacking in the literature. This entailed a Systematic Literature Review to identify important components that should be included in the framework, which included the identification of appropriate interaction design, technology, input/output software and hardware, design principles and so on, consistent with the literature and standard practices. Hence, the research addressed the outlined research challenge, by proposing an integrated multimodal interaction framework for VR stress therapy.

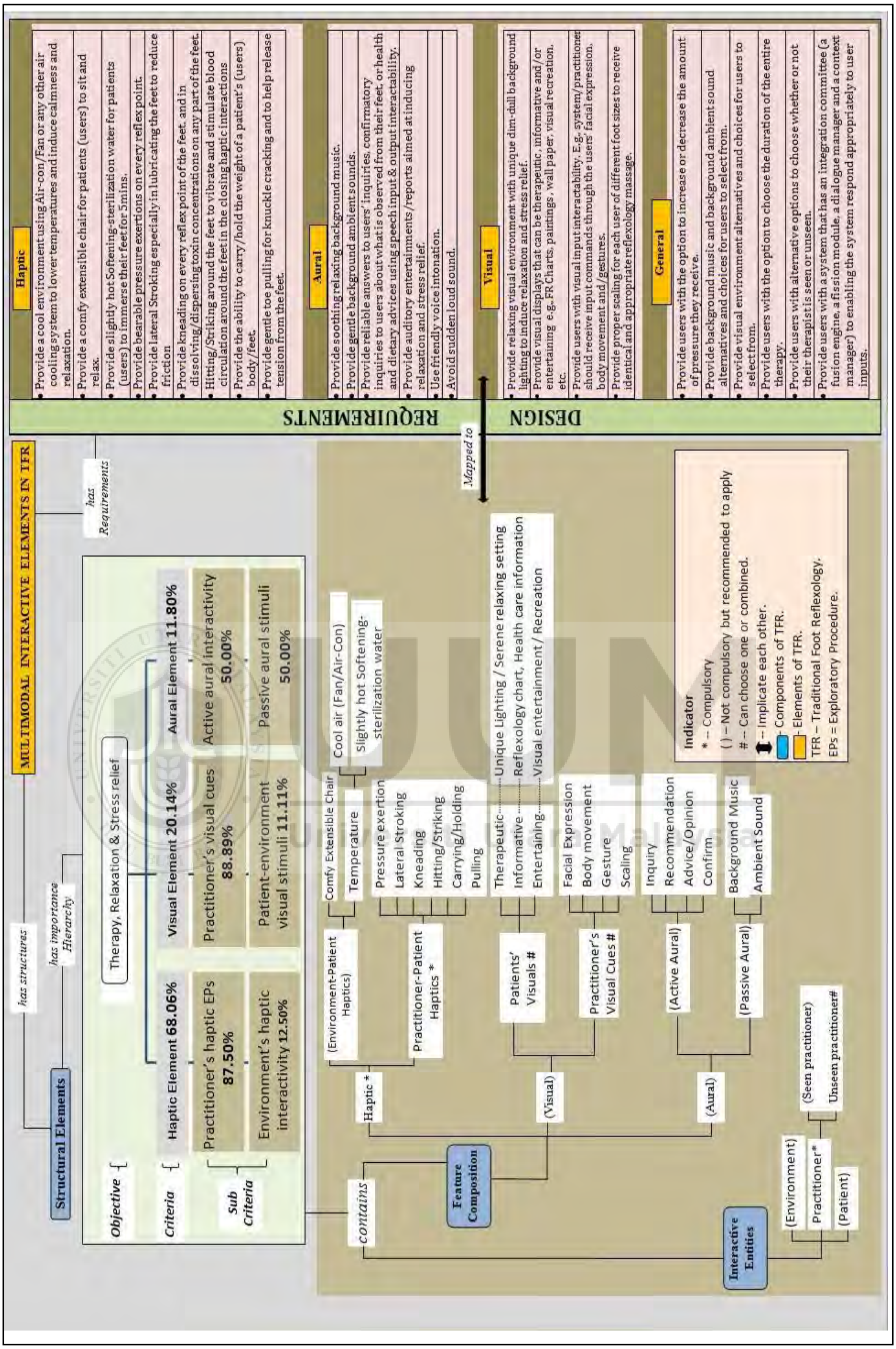


Figure 2.9. Multimodal interaction model for FR VRST Application (Sulaiman et al., 2016).

2.11 Summary

This chapter has discussed related works pertaining to the multimodal interactions, interaction frameworks and reflexology, with respect to their backgrounds, significance, application domains, and their roles for relaxation and stress relief, its respective authors and study focus. Existing VR applications can be seen in numerous domains for numerous purposes. VRST however, is proliferating domain with an increasing degree of attention. The limited researches conducted in this domain have a different focus from this research, which justified the need to conduct this research. Figure 2.10 presents the relevant topics this research reviewed as foundation for the framework development.

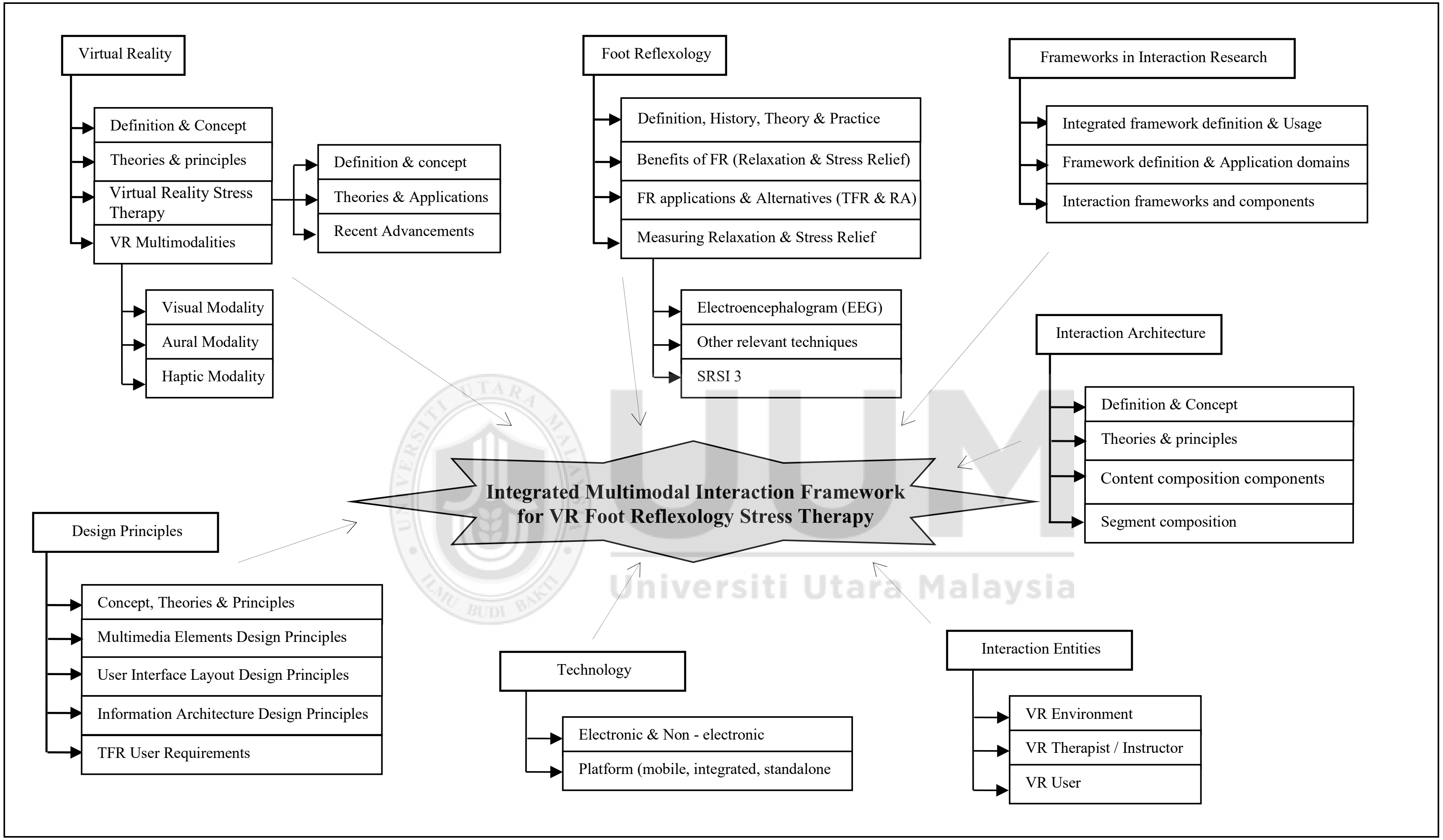


Figure 2.10. Overview of Related Literature

CHAPTER THREE
METHODOLOGY

3.1 Introduction

This chapter presents the methodological approaches, techniques, and instruments used in executing each phase of this research, in an endeavour to find answers to the research questions. As Mohrman (2007) would agree, a research methodology is a systematic procedure to accurately capture data through the involvement of several approaches. The design science research methodology (DSRM) integrates the practices, principles, and procedures needed to properly execute this research to address the research's objectives. Crabtree and Miller (1999) opined that the nature of a research problem, the objectives which it seeks to achieve, as well as the paradigm it postulates, are amongst the factors that influences and defines the choice of research method. Hence, this research utilized the design research (DS) in information system approach. Design science research is of immense importance in a discipline oriented to the creation of successful artifacts (Peffers, Tuunanen, Rothenberger, & Chatterjee, 2007). Since this research majorly aims at proposing an integrated framework and examining the effectiveness FR VRST for relaxation and stress relief as a prove of concept, through the development and testing of the prototype, the method offered the researcher with a comprehensive and systematic procedure to achieve the research's aim.

Other information that is presented in this chapter also includes the location of the research, how the study was executed, and detailed explanation on how each phase was conducted, rounds up the chapter.

3.2 Research Design

Information system design research has gained popularity as a valid and valuable research paradigm amongst researchers in recent years (Hevner, March, & Park, 2004; March & Smith, 1995). Design science research methodology was resorted to because it was felt to be the best approach for research in the IS community especially when an artifact/prototype is to be developed to address a solution (Walls, Widmeyer, & El Sawy, 2004). DSRM was formally developed and proposed by Peffers et al. (2007). The aforementioned authors highlighted that other research paradigms like in natural sciences and social sciences, that thrive through understanding reality or natural phenomena in theory-building, testing, and interpretive research, design science attempts to create things that serve human purposes (Simon, 1969).

Three main studies from the early 1990's pioneered design research into the IS community (March & Smith, 1995; Nunamaker, Chen, & Purdin, 1991; Walls, Widmeyer, & El Sawy, 1992). Walls et al., in 1992 described IS design theory as a class of research that can stand shoulder to shoulder, or equivalent to the contemporary social science based theory building and testing. Nunamaker et al. in 1991 however, recommended the integration of system development into the research process and proposed a multi-methodological paradigm that included theory building, system development, experimentation, and observations. March and Smith in 1995 then highlighted the potential of design research to contribute to the applicability of IS research by facilitating its application to address the kinds of challenges faced by IS researchers and practitioners in a more effective way.

Hevner et al. (2004) opined that design science involves rigorous processes to design artifacts to address observed problems, to make research contributions, evaluate the designs, and communicate the results to appropriate audiences. This artifact may entail a construct, model, method, instantiations, social innovations, or new properties of technical, social and/or informational resources, or any designed object with an embedded solution to an understood research problem (Hevner et al., 2004; Järvinen, 2007; Van Aken, 2004).

Hevner et al. (2004) highlighted seven guidelines that illustrate the characteristics of a well-executed research as practice rules for carrying out design science research in IS. The authors highlighted the most important of these rules being that the research must produce an artifact created to address a problem. The authors further highlighted that the artifact must be relevant to the solution of an unsolved problem. They added that it's utility, quality, and efficacy must be rigorously evaluated. The research should then present a verifiable contribution and rigor must be applied in both the development of the artifact and its evaluation. The artifact development should be a search process that is drawn from existing theories and knowledge to produce a solution to a defined problem.

3.3 Rationale of Using Design Research

The following are some of the reasons why this research is utilizing design research

i. Design research is of immense importance in a discipline oriented to the creation of successful artifacts (Hevner et al., 2004; Peffers et al., 2007). Norshuhada and Shahizan (2013) added that a valid artifact in design research can be in the form of an algorithm, working prototype, user interfaces, processes, techniques, methodologies and frameworks. And with respect to the research, it is the most suitable approach as framework and prototype development are amongst the deliverables at the end of the research's phases.

ii. Design research is concerned with the design of artifacts-constructs, models, frameworks, architectures, design principles, methods, instantiations, and design theories that address relevant issues (Vaishnavi, Kuechler, & Petter, 2017). From this research's perspective, the multimodal interaction framework for VR foot reflexology stress therapy is ultimate artifact for this research. The existence of a VR foot reflexology therapy system would enable the validation of a proof of concept of the involvement of multimodal elements playing a significant part in the relaxation and stress relief perceived by patients after therapy session.

iii. Design research concerns itself with quality end product based on efficient and effective evaluation. After the design and development of the prototype, appropriate evaluation techniques or a combination of techniques to evaluate its quality, effectiveness and efficiency.

iv. The context and design of this research matches the design research paradigm since the end product is an information system, what better paradigm to adopt than that of the information system design science paradigm.

Several researchers from the IS discipline and other disciplines (Archer, 1984; Eekels & Roozenburg, 1991; Hevner et al., 2004; Nunamaker et al., 1991; Rossi & Sein, 2003; Takeda, Veerkamp, Tomiyama, & Yoshikawam, 1990; Walls et al., 1992), contributed ideas and arguments that lead to the development of process elements and subsequently, process model which consist of six activities in a nominal sequence, presented in Figure 3.1.

Numerous researches in the VR domain have even utilized design research without knowing they have because, they fulfilled most or all the requirements of design research. Take the doctoral research conducted by Crossan (2003) for instance, on the design and evaluation of a haptic veterinary palpation training simulator. In the study, researcher identified the research problem from an investigation, and defined their objectives to develop the haptic veterinary palpation simulator. During the design and development phase, they conducted series of interview with experts to capture and gather requirements, and then followed by the development of the artifact (VR training system). This was subsequently followed by an evaluation process or validation process as with was called in the study; using several experiments to measure the usability of the system and then compared the users of the system with the users of traditional training methods. The steps followed by Crossan (2003) is almost identical to the systematic procedures outlined in design research.

Similarly, the research conducted by Nutakor (2008) on the design and evaluation of a VR training system for new underground rock-bolters. From the research, the researcher identified the need to develop a better training technique for underground rock bolters and defined their objectives to develop the MinerSim VR system for training underground miners; which was then followed by the VR system design and development. This was subsequently followed by the demonstration and evaluation process, (or deployment and evaluation as it was called in the thesis). The steps followed by Nutakor (2008) is almost identical to the systematic procedures outlined in design research (Vaishnavi et al., 2017) and as that followed by this research only with a more detailed and organized approach as shown in Figure 3.1 and Figure 3.2.

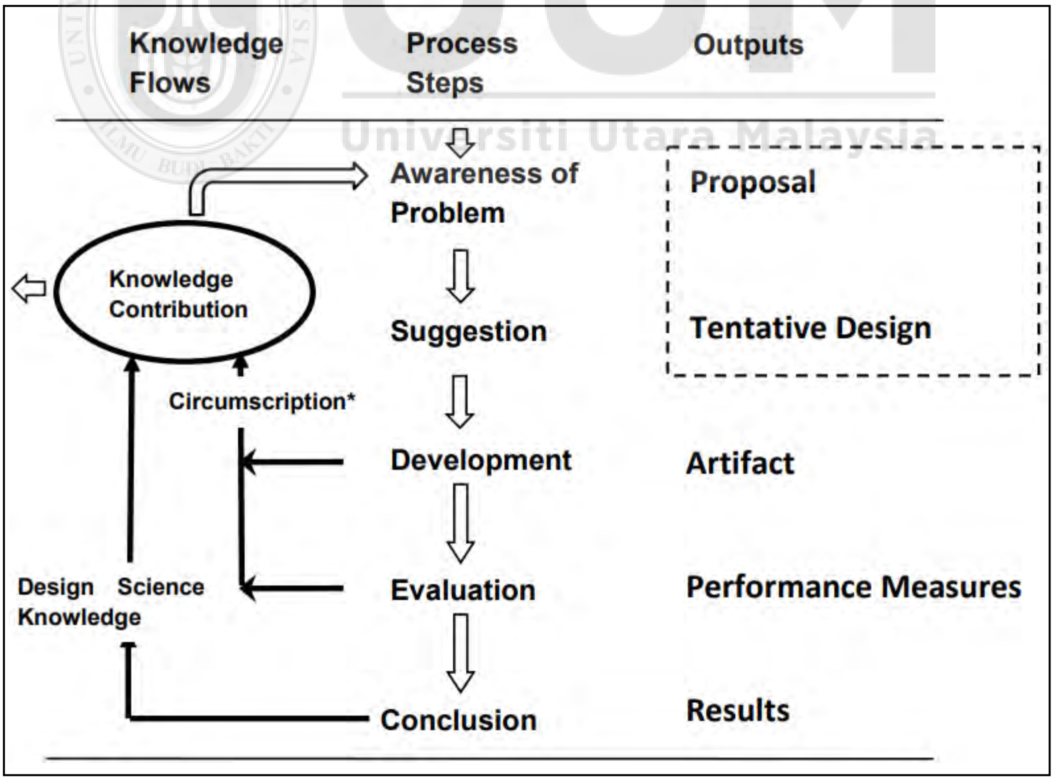


Figure 3.1. Design Science Research Methodology (DSRM) Process Model (Vaishnavi et al., 2017)

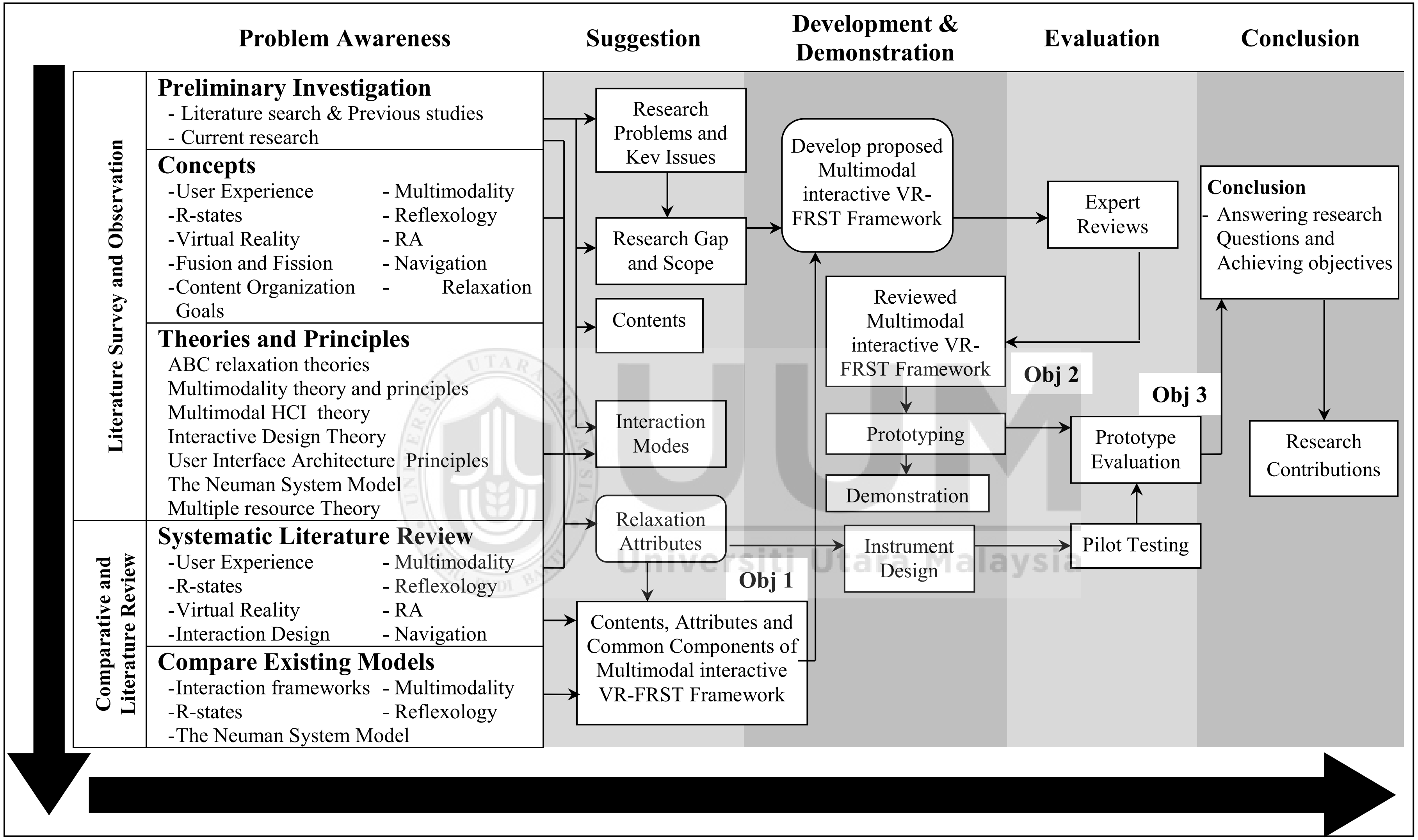


Figure 3.2. Research Process Flow *Adapted from* (Vaishnavi et al., 2017)

3.3.1 Problem Awareness

This deals with the definition of the specific research problem(s) and justifying the value of a solution, and then used to develop an artifact that can effectively provide a solution (Peffers et al., 2007). The authors highlighted that justifying the value of a solution accomplishes two things: it motivates the researcher and the audience of the research to pursue the solution and to accept the results, and it helps to understand the reasoning associated with the researcher's understanding of the problem. Resources required for this activity include knowledge of the state of the problem and the importance of its solution (Peffers et al., 2007). This phase deals with the identification of problems within a reference discipline, and the output of this phase is a formal or informal research proposal for a new research endeavour (Vaishnavi et al., 2017).

Virtual Reality Stress Therapy technologies/applications are fast becoming a predominant area of research interest as researchers are looking at utilizing the availability of VR technologies and application to enhance, complement or support life, treatment, relaxation and stress relief (Jerdan et al., 2018; Parsons, 2015; Parsons & Rizzo, 2008). Reflexology being one of the earlier mentioned alternatives for relaxation and stress combating has since become a public interest and its popularity continuously on the rise. Currently, it is widely used as complementary therapy for stress relief and a potential diagnostic tool. Coyle, (2003) stated the increasing number of preference in patients nowadays to be treated at home. According to Stephenson et al (2003), further research needs to be carried out on how foot reflexology can be provided for these patients at their homes. They further mentioned that many family members of the patients showed interest in learning how to administer reflexology for the patient. Robinson, Lorenc, and Lewith, (2011) concurred that as a result of public-driven investment on this therapy, the safety and product quality of reflexology have become one of healthcare's top research priorities. In most cases, reflexology artifacts (RA) or devices/stimulators could be used as an alternative for such practice. These artifacts or devices/stimulator enables a person to conduct self-reflexology treatment that does not incur many costs in the long run which perfectly caters for the above issue. However, the application of the therapy in a virtual space required further investigation and a proper framework. There is still a lack of multimodal interaction framework which caters for virtual reality foot reflexology stress therapy, as previous research only underlined the potential of VR in the therapy and the applicability of the therapy in a virtual space, which is still unexplored. This framework provides developers and designers in the medical and VR industry the opportunity and suggestion for a complementary therapy and reflexologist's additional therapy toolkits.

3.3.2 Suggestion

Vaishnavi et al. (2017) described suggestion as the creative step where new functionality is envisioned based on novel configurations of either existing or new and existing elements. Peffers et al., (2007) refered to this phase as defining objectives of a solution described this phase to entail inferring the objectives of a solution from the problem definition and knowledge of what is possible and feasible. The authors continued that the objectives can be quantitative, for instance, terms in which a desirable solution would be better than current ones, or qualitative, e.g., a description of how a new artifact is expected to support solutions to problems not yet addressed. These objectives should be inferred rationally from the problem specification. Resources required for this include knowledge of the state of problems and current solutions, if any, and their efficacy (Peffers et al., 2007).

Having established the value and application of VR by researchers in numerous fields, particularly in complementary therapy and health care as can be seen in the treatment of phobia through exposure therapy (VRET – Virtual Reality Exposure Therapy) (Strickland et al., 1997; Bruce & Regenbrecht, 2009); and other domains of therapy and rehabilitation (Rizzo & Kim, 2005; Weiss & Jessel, 1998; Glantz, Rizzo, & Graap 2003; Zimand et al., 2003; Rizzo et al., 2004; Schuemie et al., 2001). In VRET, multimodal interactivity is utilized to enhance the anxiety producing stimuli to increase or decrease the effect on the patient while therapeutically combating the patients' worst fear. These stimuli are usually generated as a result of the patients strong, irrational fear for certain condition or situation such as fear of heights, fear of flying, agoraphobia, fear of spider, fear of driving, fear of public speaking and so on. VRET allows the therapist to regulate the induced anxiety in adjusting the multimodal parameters of the virtual environment in the increment or decrement of the fear factor to match the users' level of tolerance. This, in turn, enhances the patients' immersion and sense of presence.

The sense of immersion or presence is relatively essential in this form of therapy as it intensifies the patient's phobic responses as concurred by the studies reviewed and reported by Strickland et al (1997), which indicated that VR scenes can produce a variety of phobic symptoms, and the incorporation of sound and touch such as a furry spider greatly intensified the experience. In supporting the research gap, the findings from previous studies were explored extensively, leading to the formulation of the research objectives scope, contribution to the body of knowledge, and subsequently the identification of the contents, attributes, and common components of the multimodal interaction framework for VR-FRST.

3.3.3 Development and Demonstration

Other researchers described this phase to involve the creation of an artifact which may entail a construct, model, method, instantiations, social innovations, or new properties of technical, social and/or informational resources, or any designed object with an embedded solution to an understood research problem (Hevner et al., 2004; Järvinen, 2007; Van Aken, 2004). Vaishnavi et al. (2017) expressed that the implementation itself may be very ordinary and does not need to involve novelty beyond the state-of-practice for the given artifact; i.e., the novelty is basically in the design, not the construction of the artifact itself. Peffers et al., (2007) described this phase to include determining the artifact's desired functionality and its architecture and then creating the actual artifact. Resources required moving from objectives to design and development include knowledge of theory that can be brought to bear in a solution (Peffers et al., 2007). With respect to this research, it entailed two (2) phases: the framework development, and prototype development.

3.3.3.1 Framework Development

This phase entailed the identification of the components of the multimodal interaction framework for VR foot reflexology stress therapy and the actual integration and design of the framework. An SLR was carried out to identify the multimodal interactive components by using "VR stress therapy", "VR framework", "multimodal interaction framework", and "mobile VR" as keywords. During the systematic literature review, three criteria were used as criteria for selecting articles/resource, which are: (1) the study was published no later than 2005. (2) Published in a reputable journal of HCI and/or VR. (3) Revealed/discussed components or elements of the interaction framework. However, notable articles, thesis and proceedings beyond 2005 worthy of mentioning which also contributes to identifying the relevant components of the interaction framework as shown in Table 3.1, was also reviewed and selected for inclusion.

Table 3.1

List of selected journals titles in HCI and VR, alongside candidates and selected papers

Journal Title	**Journal Acronym**	**Publisher**	**Candidate**	**Selected**
Computer in Human behaviour	CHB	Elsevier	57	6
International journal of Human Computer Interaction	IJHCI	Taylor & Francis	47	5
Interacting with computers	IwC	Elsevier	53	2
International Journal of Mobile Human Computer Interaction	IJMHCI	IGI Global	61	6
Journal of Virtual Reality	JVR	Springer London	24	4
Others	Journals, Thesis & proceedings		82	7
	Total		324	30

3.3.3.2 Prototype Development

The development method of the prototype utilized the prototyping approach as adapted from (Laudon & Laudon, 2009). This approach involves three stages which include developing initial proto-type, using prototype, and revising and enhancing prototype as shown in Figure 3.3. Each of the aforementioned stages in the prototyping approach involved sub steps or phases and outcomes. The outcomes from each stage are passed on to the next stage and so on. The entire process is iterated till a satisfied prototype is achieved.

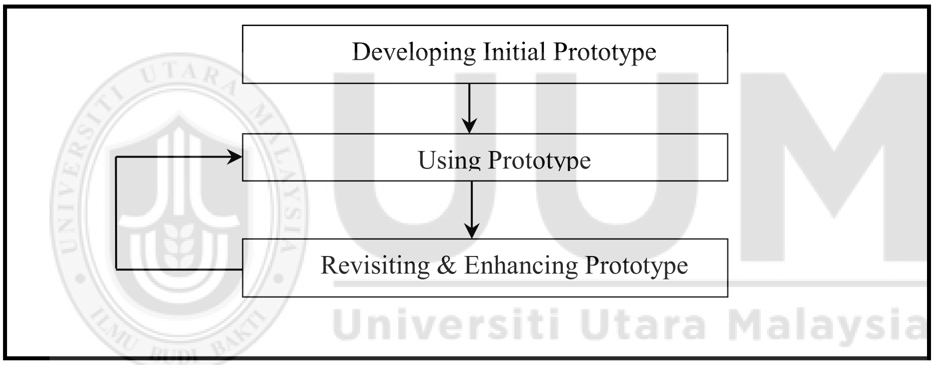


Figure 3.3. Prototyping Approach (Laudon & Laudon, 2009).

VR-Foot-ReST application was developed using Unity 3D for Android Smartphone. After publishing into Android APK, the APK is installed and ran in an Android smartphone for testing. C# programming language was used to write the codes and scripting while the Unity environment was used to design the interface of the proposed VR-Foot-ReST application. Photoshop 7 (Image Processing Program) was used to create and modify the required images, photos and icons. Audacity 2.0 (An open source Digital Audio Editor) was used to record and edit the required audios.

These audio files were exported into MP3 format for size portability and compatibility in Unity 3D. Finally, Adobe Premier Pro was used to design and edit all the required videos and published into MP4 for size and graphic compatibility in Unity 3D.

i. Developing Initial Prototype

This stage involved three activities which include requirement gathering, content preparation and prototype development. The activities are as follows:

a. Requirement Gathering: The required information and requirements which should be in the prototype contents which include all the visual, aural and haptic content were identified, outlined, and verified before they can be used in the prototype. Leading up to the development of this VR-Foot-ReST application, the human to human (H-to-H) multimodal interactions contained in the traditional foot reflexology therapy was revealed by (Sulaiman et al., 2016). Subsequent study saw the design requirement and an interaction model developed from the H-to-H multimodal TFR interactions, expert reviews were then utilized for validation (Sulaiman et al., 2016).

b. Content Preparation: This involves the preparation of contents to be used for or during the development of the proposed prototype like image preparation (all the required images for the VR-Foot-ReST prototype was created or edited using Adobe Photoshop. Especially big sized images were processed and converted to smaller sizes, and saved in smaller compatible file formats, suitable to the mobile screen size. The required icons like the system icon and button icon was also prepared using Photoshop; those icons were created and saved in PNG format), audio preparation (all the required audios for the VR-Foot-ReST prototype like the welcome and introductory speech, instructional speeches, rainforest waterfall nature ambience sounds, 432Hz Miracle Positive Energy Healing background tone) were recorded/Edited/Converted using Audacity 2.0. The MP3 extension has been chosen for the audio format since it is supported by many types of mobile phones. And besides MP3 audio formats are conspicuously smaller in size as compared to other file formats like .wav and so on), video preparation (all the required videos for the VR-Foot-ReST application are prepared/edited and exported to MP4 format for use in the application. Like the 360 nature-waterfall environment to immerse the VR user, the instructional progressive user relaxation exercises consistent with the interaction principles of the selected haptic device/artifact, subtitles and incorporated texts were all created / edited using Adobe Premier Pro), software/hardware preparation (the software and hardware used for the development of the respective multimodal contents, and the input/output enablers with which users can multimodally interact with the VR-Foot-ReST application like the Android mobile phone with in-built microphone, speakers/headphones, screens/monitor, the mobile phone HMD (Samsung VR Gear), and reflexology slippers).

c. Prototype development: During the prototype development, Unity 3D game engine environment was used to develop VR prototype. All the prepared contents in the previous stage were imported into the Unity 3D asset folder and development began. C# programming language was used for scripting and coding. Finally, after the development was completed, an APK file was created and ready for installation on an Android platform.

ii. Using Prototype

The APK file which was produced in the previous step was installed in Android mobile phone (Samsung Galaxy S) that has a 3.7 inch screen size for testing. This was then followed by inserting the Android phone into the Android HMD compartment. During the system testing some notes were taken to improve and enhance the next version of the prototype like the font size, object adjustments, audio & video content adjustments, image size and so on.

iii. Revising and Enhancing Prototype

In this step 3 mobile application developers tested each version of the prototype using the framework as the guideline to compare and take notes on how to adjust, amend and/or enhance the current version so as to conform to the guidelines laid out by the framework and standard practice. This was then applied to the subsequent prototype versions iteratively until the desired prototype version was attained.

3.3.3.3 Demonstration

Just as the name implies, this phase involved demonstrating the artifact to domain experts, to prove that the idea works.This may involve its utilization in experimentation, case study, simulation, or any other suitable activity (Peffers et al., 2007). The author continued that the needed resources required in this phase is the valuable knowledge or know-how on the usage of the artifact to address the aforementioned problem (Peffers et al., 2007). In this phase, two (2) certified and experienced medical or complementary practitioners were employed with expertise in either complementary therapy, massage therapy, stress therapy, nursing care, foot reflexology and/or related areas; and have been practicing in said area for at least ten (10) years. These experts reviewed the prototype Virtual Reality Foot Reflexology Stress Therapy application (VR-Foot-ReST) aimed at offering VR and as an alternative for Traditional foot reflexology in relaxation, stress relief and complementary therapy. These medical or complementary therapy practitioners provided insights on the prototypes efficiency, safety, internal components, psychological and physiological implications, and an overall overview of the prototype before it is being tested on users.

These practitioners were contacted and a convenient time was scheduled to visit them at their practicing centre, where they tested the VR-Foot-ReST prototype and the follow-up interview ensued. They were first given a consent form to consent their participation in the study, having prior explained in detail their role and contribution to the research. After which the prototype was set up and given to them to use. They were then interviewed right after going through the therapy using the VR-Foot-ReST application. The interview questions and answers with the complementary therapy practitioners are presented in Appendix A.

3.3.4 Evaluation

This phase was explained by Peffers et al., (2007) to involve observing and measuring how effective the proposed artifact corroborates as a solution to the problem. This entails the comparison of the aforementioned objectives to the actual observed results demonstrated by the use of the proposed artifact. The evaluation phase requires knowledge of relevant metrics and analysis techniques, which could take many forms depending on the nature of the problem venue and the artifact. Vaishnavi et al. (2017) expressed that the proposed artifact is evaluated based on criteria that are implicit and frequently made explicit in the problem awareness phase. Vaishnavi et al. (2017) also expressed that any quantitative and qualitative deviations from expectations are cautiously noted and must be clearly justified. It is therefore safe to say that this phase involves the analyses or outlining of hypotheses on the behaviour of the proposed artifact. Peffers et al. (2007) expressed that this phase highlights the empirical evidence or logical proof..

3.3.4.1 Integrated VR-FRST Framework Evaluation

In the evaluation of the VR-FRST framework, the expert review process was applied to evaluate the proposed framework. Expert reviews are a generally accepted process for quality improvement; this is due to the effectiveness and cost-efficiency of this process in discovering the challenges, issues, and problems with an existing design, deliverables, framework, or document (Radice, 2001; Wiegers, 2002). The process entailed the domain experts or evaluators to utilize their experience and knowledge in that particular domain to evaluate and enhance the design, deliverables, framework, or document. Hence, the study employed experts in are either in Human

Computer Interaction (HCI) or Multimedia or Mobile Applications or Virtual Reality (VR) or Information Systems (IS) or Computer Science (CS) and/or related areas to evaluate the framework. These experts must have been teaching / researching in VR or Multimedia or HCI or interaction designs or IT and/or CS areas for at least five (5) years. The expert evaluations and review feedbacks were used to revisit the proposed framework and address every issue, concerns or challenges raised by the experts.

3.3.4.2 VR-FRST Evaluation for Relaxation and Stress Relief Using SRSI-3

This phase presents a proof of concept in the form of an evaluation of the virtual reality foot reflexology prototype on relaxation and stress relief. The quasi - experimental study design, also called interventional study designs is utilized for this study (pretest–posttest design in particular). This study design involves the researcher intervening at some point during the study (Thiese, 2014). The basic premise behind the pretest–posttest design entails the acquisition of a pre-test measure of the outcome of interest before the administration of treatment, then followed by measuring the post-test of the same measure after the treatment administrations. According to Salkind (2010), these pretest–posttest study designs can be “employed in experimental and quasi-experimental research, and can be applied with or without control groups”.

i. Instrument

The study adapted the Smith Relaxation States Inventory 3 (SRSI-3), which is the latest expanded edition of the SRSI’s. The ABC relaxation theory (Smith, 2001) proposed that all approaches to relaxation have the potential of evoking one or several of the 4 relaxation states or (R-states) categories: Basic Relaxation (R-States: Sleepiness, Disengagement, Physical Relaxation, Rested / Refreshed, and Mental Relaxation); Core Mindfulness (Acceptance, Quiet, Centering, Aware / Focused / Clear, Awakening, and Innocence); Positive Energy (Joyful, Optimistic, Energized, Thankful/Loving); Transcendence (Awe and Wonder, Reverent/Prayerful, Mystery, and Timeless / Boundless / Infinite / At One) (Barlow et al., 2007; Smith, 2007b, 2007a). The SRSI-3 also measures users' stress states (Somatic Stress, Emotional Stress, and Cognitive Stress). It asks participants to indicate how they feel "now, at the present moment" on a 6-point Likert scale from 1 (not at all) to 6 (maximum). The Smith Relaxation States Inventory have revealed differences among relaxation activities and techniques, including Progressive Muscle Relaxation, breathing exercises (Matsumoto & Smith, 2001), yoga stretching (Ghonchec & Smith, 2004), as well as a wide range of casual-relaxation activities (Smith, 2001). This instrument was administered to the participants before and after the intervention in this quasi-experimental study, to measure participants current "Stress-state" and "Relaxation-states" before and after the stress therapy procedure. The Smith Relaxation States Inventory III consists of 38 items. The R-state inventory version (SRSI3s) asks the respondent how they "feel right now" on 6-point Likert scale (1 = "not at all", 6 = "maximum").

ii. Instrument Validation

There are two fundamental ways in which research instrument can be validated, these are: content validity and construct validity.

Content Validation

Content validity of an instrument is very important and must be conducted before the main collection of data. According to Sekaran and Bougie (2009), it can be achieved through face validation of the instrument. The adopted instrument in this study was given to a research methodology expert, to see if there is any mistake in the instrument developed. This was done specifically to avoid issues of double barreled question and ambiguity in the research instrument.

Construct Validation

Sekaran and Bougie (2009) concurred that construct validity is usually tested by determining the internal consistency of a construct. In achieving this, the reliability of the construct was tested by determining the cronbach's Alpha level, which interpreted the reliability of the item of each variable constructs. A Cronbach alpha greater than 0.6 for an experiment of this manner research is considered as appropriate, while Cronbach alpha below 0.6 indicates unreliability. The researcher has to decide either to go for another data collection or drop the construct in case of a low reliability result (Sekaran 2000). 15 respondents were particularly used as the pilot sample in this study.

iii. Pilot Testing

Upon the completion of the organizing and presentation of the instrument, a pilot study is required to be the next step in order to provide confidence for the researcher. A pilot study is referred to as a trial run or a mini version of a research carried out in preparation to the main study and may be executed particularly to pre-test a research instrument (Teijlingen & Hundley, 2001). A pilot study is very useful in both quantitative and qualitative research (Tashakkori & Teddlie, 2010). Several researchers have underlined the clear significance of carrying out pilot studies the foundation to any research as it provides the function of helping to detect probable flaws in the measurement instrument, or if the concepts have been operationalized properly (Teijlingen & Hundley, 2001; Watson, Atkinson, & Rose, 2007). Hence, pre-testing the instrument on a smaller participant sample with similar characteristics to that of the main study, achieves the aforementioned aim of a pilot study. In addition to that, interviewees are sometimes said to be biased during data collection, especially if they don't understand the questions asked of them (Sekaran & Bougie, 2009). Van Wijk and Harrison (2013) also expressed that pilot testing add credibility and value to the entire research. The essence of this was to ensure the researcher that the respondents comprehended the content of the questionnaire developed. A pilot test was carried out before the main study to improve the questionnaire's quality via the feedback and the suggestion from the pilot sample. In furtherance, the interview protocol was designed in a flexible and understandable manner. This approach is in line with the guideline presented by Creswell (2012) who stressed that questions should be constructed in such a way to retain participants' focus to their responses to the questions.

According to Sekeran (2003), and Chau and Hu (2001), it was suggested that, sample population for pilot study should not be necessarily big. Therefore, 15 respondents were selected for pilot test in this study. According to Hair et al., (2010) the acceptable threshold for the reliability is 0.60 and above. The result of the pilot study revealed that the Cronbach's Alpha obtained for the items under each variable is reliable (Mindfulness = 0.834, Positive Energy = 0.785, Basic Relaxation = 0.832, and Stress = 0.696) except for Transcendence. The initial Cronbach's Alpha for Transcendence was 0.556, which is below the 0.6 threshold. However, after computing the Cronbach's Alpha if item removed, the item "*Things seem TIMELESS, BOUNDLESS, or INFINITE?*" for Transcendence was excluded and the Cronbach's Alpha for Transcendence improved to 0.630, which is above the threshold of 0.60. Hence, the study achieved confirming the reliability of the instrument as shown in the Table 3.1. The final copy of the study instrument is presented in Appendix B.

Table 3.2

Result of Pilot Test

No	Variables	Items	Cronbach's Alpha
1	Transcendence	3	0.630
2	Mindfulness	9	0.834
3	Positive Energy	6	0.785
4	Basic Relaxation	11	0.832
5	Stress	8	0.696

iv. Main Study

In order to achieve the final objective, the effectiveness of the multimodal interaction framework for Virtual Reality Foot Reflexology Stress Therapy on relaxation and stress relief had to be evaluated. A single-group, pretest–posttest, quasi-experimental research design and convenience sampling was utilized in this study. 30 participants (n=30) participated in the study. These 30 participants participated in the study, and had a 10–12 minutes VR foot reflexology session using VR-Foot-ReST application. Participants were recruited from a workshop organized by the Counselling Centre of Universiti Utara Malaysia entitled *"How to cope with stress"*; stress that is particularly related to students' academic and personal life. The workshop was organized based on the counsellors Act 1998 (Act 580). This offers a safe atmosphere where personal concerns are openly discussed and explored with professional counsellors. Participants were invited to the study if they: a) were students of Universiti Utara Malaysia, b) possessed a proficiency in understanding and communicating in the English language, and c) feel they were stressed. In addition to that, participants were excluded if they: a) were expectant with child, and b) were under constant medication or had critical medical conditions that required hospitalization. These criteria were excluded as they might influence or confound research findings. The participants recruited were notified of the nature of the experiment and the contact information of interested participants was collected for further communication and follow-up. Over seventy-five (75) invitations were distributed; about fifty (50) consented, and established interests. Amongst the fifty (50) that consented, only thirty (30) of them honoured the invitation. These thirty (30) were utilized for the study. These participants were invited to the Virtual Reality Research cluster Laboratory, where the study was conducted. The study adopts the Smith Relaxation States Inventory 3 (SRSI-3), which is the latest expanded version of the SRSI's. This inventory assess relaxation states also known as the "R-States" (Smith, 2001; Smith et al., 2000). These R-states are categorized into four (4): Basic relaxation; Mindfulness; Positive Energy; Transcendence. The SRSI-3 also measure participants for their stress-states. This instrument was administered to the participants before and after the intervention in this experimental study, to measure participants current "Stress-state" and "Relaxation-states" before and after the stress therapy procedure. The participants completed the SRSI-3 (pre-test), utilize the VR-Foot-ReST, and then completes the SRSI-3 (post-test).

To minimize possible confounding factors (external validity); firstly, the Samsung VR HMD and JBL Bluetooth wireless earphones were properly placed on the users' head and ears to enhance immersion, presence, engagement and suspension of disbelief, which may be influenced by external factors like external noise or any external visual interference. Secondly, these respondents were measured before and after the intervention, i.e., about 12 minutes apart (duration of the therapy session). It is therefore reasonable to conclude that any change in the users' relaxation and stress state is as a result of the VR-FRST intervention. Thirdly, the same researcher collected both the pre-test data and post-test data from all the respondents. Finally, the same physical environment (such as venue and room temperature) was utilized to collect and examine all the pre-test and post-test scores.

Hence, the researcher hypothesized that:

- *VR foot reflexology stress therapy users will report an increased "R-states" in at least one of the four (4) relaxation state categories; and reduced stress-states.*

v. Research Ethical Consideration

The researchers' choices of procedural investigation are grounded by standard principles called ethical consideration. Bryne and Bell (2003) expressed that researchers must follow ethical behaviour in the execution of their study to avoid infringing on the participants' rights. Ethical considerations ensure that high research qualities and standards are held as seconded by Zikmund et al. (2005). Likewise from the perspective of this research, the researcher ensured that the following ethical considerations highlighted by Bouma (2000) were held up during data collection for the study:

- The study did not require participants to take any medications or undergo any medical procedure, but only give feedback on their perceived stress and relaxation states. Hence, the research ensured that the prototype was safe to use with no adverse effect and approved by medical experts during the demonstration phase.
- The researcher treated each participant with dignity and respect
- The researcher ensured that participants' privacy and confidentiality were emphasized.
- The researcher ensured that none of the participants were not forced to participate in any phase of this research, but voluntarily participated. The researcher obtained a verbal or written consents from all the participants
- The researcher ensured that the participants were guaranteed that any information supplied in this study would be utilized for the consented purpose of this research and academic purposes only.
- The researcher ensured that the participants were informed of their right to freely pull out from participating in the research at anytime.

vi. Method of Data Analysis

Statistical analysis was used to analyse the data collected in this study using SPSS (v. 22) which is an acronym for Statistical Package for Social Sciences. This ascertained whether or not the proposed hypotheses are supported. Before the actual data analysis, the data were first prepared and screened using data editing, data coding, data omission and data transformation was carried out to make sure that the data is fit and appropriate for the eventual and actual data analysis. The details of the statistical techniques applied in the study are discussed further in Chapter 6.

3.3.5 Communication

This phase involves the dissemination of the results, knowledge, and findings to the appropriate audience as seconded by Hevner et al. (2004). These are both medical and technology oriented audiences. At this stage, the research problem and its relevance, the remedy or artifact, its efficiency, the novelty and its effectiveness, are disseminated to other researchers and relevant audiences (Peffers et al., 2007), in the form of journal articles, conferences, thesis write-up and presentation.

3.4 Summary

The chapter highlighted in detail the systematic procedure and methodology employed to tackle the aforementioned objectives outlined in Chapter 1 towards the successful execution and completion of this research. Design science research method was employed and unanimously identified by researchers as being significant in a discipline which aims at the development of good artifacts. The design science research method targets an end product that has high quality rooted in an effective and efficient evaluation.

CHAPTER FOUR
INTEGRATED MULTIMODAL INTERACTION FRAMEWORK FOR VR – FRST

4.1 Introduction

The major objective of the entire research is to design a multimodal interaction framework for virtual reality foot reflexology stress therapy in a systematic and holistic manner, which will guide designers in creating a consistent and coherent multimodal VR stress therapy system, and also allow for an accurate and consistent formation of a mental model across applications. The aforementioned goal is achieved by addressing the fundamental research questions outlined in chapter 1.

What are the components of the integrated multimodal interaction framework for VR-FRST?

In the following phases, the researcher elaborated and analysed each component of interaction framework, so as to highlight properly and establish the foundations for the subsequent phases.

4.2 Analysis of Interaction Framework

There is no standard definition of an interaction framework within the research community, best known to the researcher. Hence, is subject to any individual researchers' subjective definition. However, Ni (2011) opined that a framework is a structure that consists of several interrelated components: input device, interaction techniques, and fundamental design principles and practical design guidelines as shown in Figure 4.1. This is also consistent with the multimodal representation of man-machine interaction cycle by (Dumas et al., 2009) as presented in Figure 2.5, with the inclusion of interaction technique by the former in the process, and refered to as fission and fusion. The input device(s) collect information/communication from the user to the system, processed into machine-interpretable information through a process called fusion by Dumas et al. (2009). The system then provides apropraite feedback through fission using the appropraite modality (Dumas et al., 2009; Ni, 2011). Ni (2009) further added that the design principles and guidelines allow designers to make appropraite design choices to create effective interaction loop.

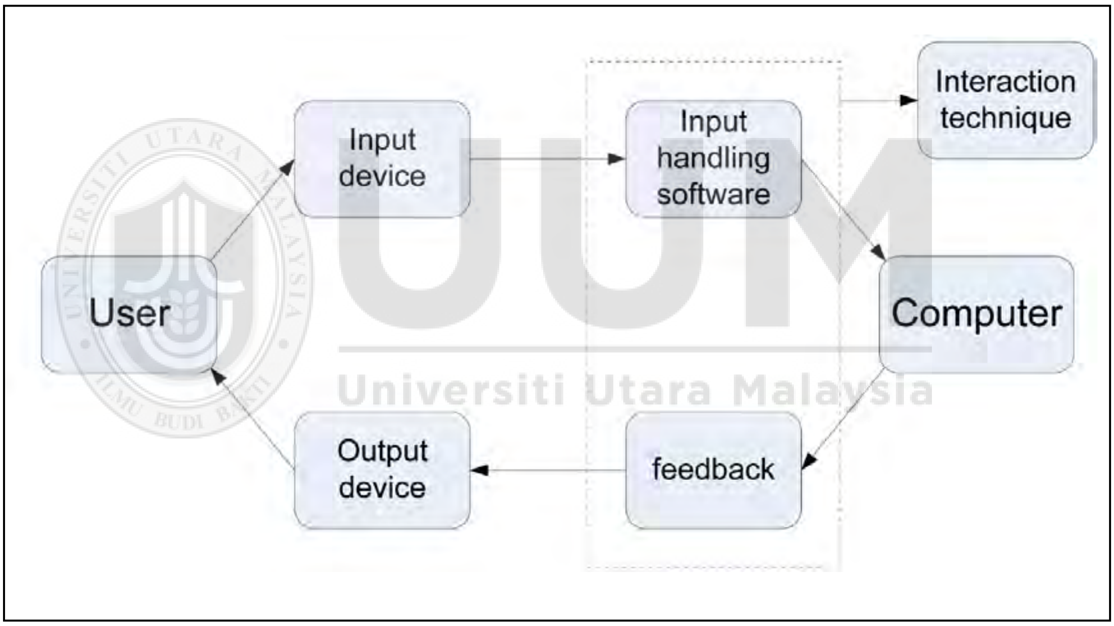


Figure 4.1. Human-computer interaction loop (Ni, 2011)

4.3 Our Approach to Multimodal VR – FRST Interaction Framework

This section generally presents the generic components that form the proposed VR-FRST Framework. Angkananon and colleagues conducted a series of studies which developed a general interaction framework, an extension of the work of Dix (1994) and Gaines (1988), aiding the design of technology to enhance communication and improve interactions between people, technology and objects, especially in complex situations (Angkananon et al., 2013c, 2013a, 2013b, 2014). The aforementioned authors argued that most frameworks are incomplete as the reviews they conducted on interaction frameworks revealed that most frameworks concentrated on people-people communication and interaction, technology to enhance communication. Several frameworks address many interactions between humans and computers (Dix et al., 2004; Sung et al., 2010), and miss out on some important interactions like the interaction between people technology and real objects, or People-People interaction, People-Objects interaction, People – Technology interaction, People-Technology-People interaction, People-Technology – Objects interaction. Consequently, they proposed a technology enhanced interaction framework which is claimed to be complete as it addresses every missing and necessary component of other frameworks as shown in Table 4.1.

Table 4.1

The major component of Technology Enhanced Interaction Framework
(Angkananon et al., 2013c, 2013a, 2013b, 2014)

Main Component	**Main Component of Technology Enhanced Interaction Framework Role** ***Sub-component***	***Examples***
People	Role	speaker – audience (e.g. teacher – student ; owner – visitor), peer-peer
	Ability/disability	physical disability, sensory disability, language, culture, communication, Information Technology (IT)
Objects	Dimension	2 dimensional (2D), 3 dimensional (3D)
	Property	colour, shape, size
	Content	human readable (text, pictures, audio, video), machine readable (QR codes, AR tag, barcodes, RFID tag, NFC)
Interaction and Communication	People-People(P-P)	verbal communication (speak, listen, ask, answer), non-verbal (lip-read, smile, touch, sign, gesture, nod), deixis (refer)
	People-Objects(P-O)	control (touch, hold, move), information retrieval: knowledge (look, listen, read, remember colour, shape, size),

Table 4.2 continued.

		meaning objects (understand)
	People-Technology (P-T)	control (hold, move, use compass, type, scan, take photo, press, swipe), information transmission and storage (send information, save, store, search online or offline document, retrieve)
	People-Technology-People(P-T-P)	control (send sms, mms, email, show information, chat), information transmission and storage (send information, save, store, search, retrieve)
	People-Technology-Objects(P-T-O) Technology	control (point, move, hold, scan QR codes, scan AR tag, use camera, use compass), information transmission and storage (send information, save, store, search, retrieve)
Technology	Electronic (store information in technology)	online, offline, content, non-content, mobile, non-mobile
	Non-electronic (store information in objects)	content, non-content, mobile, non-mobile
	Interface	website, mobile website
	Application or service	mobile website, mobile application
	Cost	hardware, software, staff
Time/Place	Place	same place (SP), different place (DP)
	Time	same time (ST), different time (DT)
Context	Location	indoor/outdoor
	Weather condition	rainy, cloudy, sunny, windy, hot, cold, dry, wet
	Signal type and quality	broadband, GPS, 3G
	Background Noise	background music, crowded situation
Interaction layer	Culture	gesture, language
	Intentionality	understand, purpose, benefit
	Knowledge	Facts, concepts, principle
	Action	touch, move, type, swipe
	Expression	whether action is correct, accurate, prompt
	Physical	colour, size, shape

Consistent with Angkanon and colleagues (2013a, 2013b, 2013c, 2014), Al-Aidaroos (2017) similarly proposed a conceptual framework for usable multimodal mobile assistance during hajj, using similar components of content composition, humand entities, structural composition, design principles, development approach, and technology. Consequent to the SLR, a number of possible framework components were discovered and 5 of them in categories were selected for inclusion in the framework as majority of other elements fell within these selected categories or at least contributed to the components properties as shown in Appendix D. These include: interaction entities, technology, segment composition, content composition, and design principles and guideline.

Table 4.2

Summarising the review of the interaction framework components

	(Larson et al., 2003)	(Beaudouin-lafon, 2004)	(Foulger, 2004)	(Karam, 2006)	(Klink, 2006)	(O'Brien, Rogers, & Fisk, 2008)	(Chorianopoulos, 2008)	(Rukzio et al., 2008)	(Dumas et al., 2009)	(Vyas et al., 2008)	(Lee, Armitage, Groves, & Stephens, 2009)	(Petrie & Bevan, 2009)	(Sung et al., 2010)	(Ni, 2011)	(Martens & Antonenko, 2012)	(Rahim, Abd Hamid, Wan Isa, Mohd Satar, & Rozaimee, 2013)	(Angkananon et al., 2013c, 2013a, 2014)	(Y. Lu, Kim, Dou, & Kumar, 2014)	(Suziah Sulaiman et al., 2016)	(Shneiderman et al., 2016; Shneiderman, Plaisant, Cohen, & Jacobs, 2009; Shneiderman & Plaisant, 1987)	(Al-Aidaroos, 2017)	(Lindner et al., 2017)	(Apple Developer, 2018b)
Entities	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓	
Technology		✓			✓			✓			✓		✓				✓		✓		✓	✓	
Structural/Segment component			✓					✓		✓		✓	✓			✓			✓		✓		
Content composition / Interaction Architecture	✓	✓	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓		✓	✓		✓		✓	✓	
Design principles & guidelines	✓	✓			✓	✓	✓	✓				✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

4.3.1 Users / Interaction Entities

From the Figure 4.2, it can be deduced that there are three distinctive interaction categories that are involved in the overall multimodal interactivity in TFR which includes: practitioner to patient interaction, patient-practitioner interaction, and environment to patient interaction as shown in the Figure 4.2.

4.3.1.1 Practitioner-to-patient interaction

The practitioner-to-patient interactions are mono-directional interactions that are initiated by the reflexology practitioner to perform a specific task on the patient to achieve the desired purpose. From Figure 4.3, the two practitioner-to-patient interactions involved in TFR are the haptic exploratory procedures and visual cues captured by the practitioner.

i. *The haptic exploratory procedures* are the touch action performed by the reflexologist's hands on the patient's feet in the course of the therapy. (Chimeremeze, Sulaiman, Rambli, et al., 2014) underlined that foot reflexology is a haptic dominant domain, and that these haptic interactions are the most important interactions in foot reflexology as compared to the other visual and aural interactivities. The haptic exploratory procedures conducted by the practitioner throughout the course of the therapy includes pressure exertion, tapping, kneading, lateral stroking, pulling/stretching, holding/carrying, from which the patient perceives either pain, sweet pain, bitter/sour pain, itchy feeling, or ticklish feeling (Okere, 2015). Alternative to using the finger to massage the patient's feet, the reflexology practitioner uses a hard stick with a knuckle-like edge to massage, especially for those patients whose sole of their feet are hard and not so soft.

ii. *The Visual Cues* involves body movement or facial expression in response to the haptic or touch interaction on the patient's foot. The practitioner catches the visual cues from these patients to measure the degree of pain bearable by the patient or the level of satisfaction or pleasure being experienced by the patient. Or the practitioner's ability to detect a problem/injury or a potential problem with a patient's organ by observing acute or sharp response to a supposedly bearable pressure that corresponds to its relative organ before asking the patient some diagnostic questions for confirmation (Okere, 2015). Alternatively, the practitioner just verbally inquires to get confirmation of whatever the practitioner notices or wishes to know.

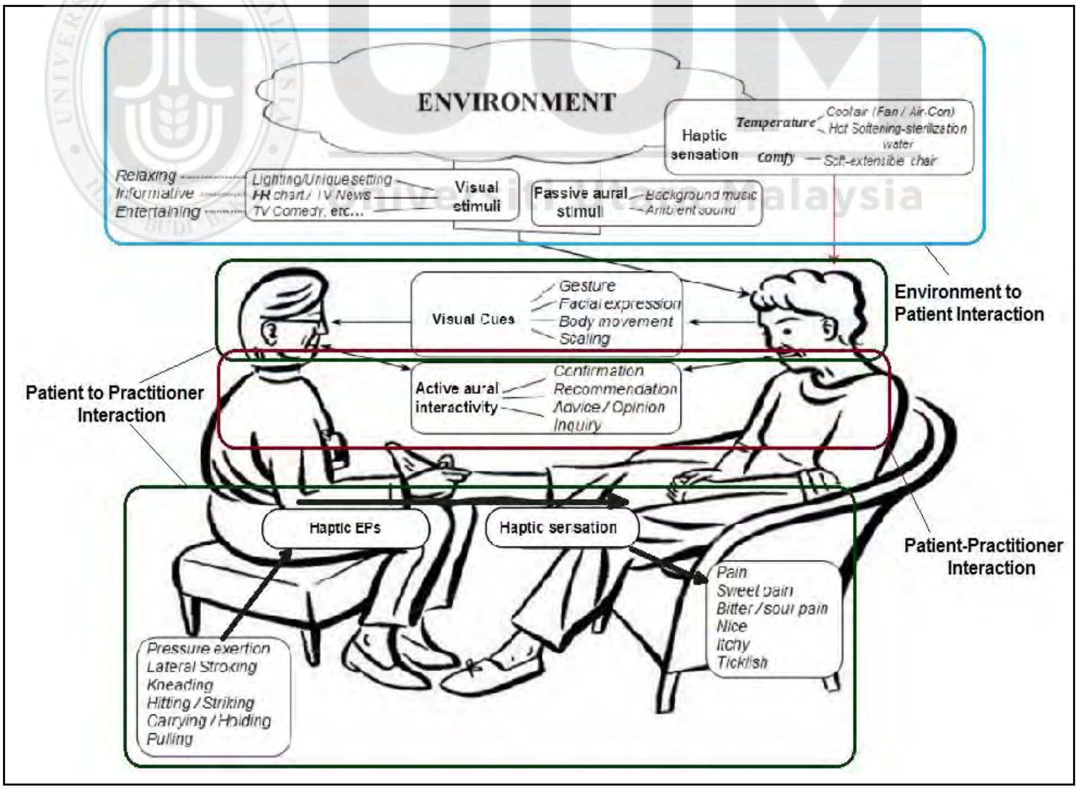


Figure 4.2. Classification of interactivity in TFR

4.3.1.2 Practitioner and patient interaction

Practitioner and patient interaction are bi-directional active aural/verbal communication between the practitioner and the patient. This active aural communication may be confirmations, recommendations/advice, information/inquiry, opinion sharing.

i. *Confirmations* – during therapy, medical concerns are noted by the therapist when need be (like sleeping or eating disorder, or potential problems with an internal organ) and inquire from the patients to clarify or affirm these observations. Or alternatively asks the patient how they feel to gauge the amount of pressure being exerted on the patient's foot.

ii. *Recommendations/Advice* – in the course of the therapy, Okere (2015) expressed that certain recommendations or advice are given to patients to enable them improve their health, and sometime the therapists refer them to other physicians for suitable medical diagnosis and care.

iii. *Information/Inquiry* – in the course of the therapy, patients sometimes ask some frequently asked questions to inquire about reflexology, its connections to the reflex points and other parts of the body, and so on (Okere, 2015).

iv. *Opinion Sharing* – sometimes in the course of the therapy, "some patients request the therapist's opinion on certain subjects (emotional, personal, political, environmental, social or economic opinions)". Okere (2015) expressed that certain patients see these dialogues to be "therapeutic or relaxing, or entertaining", which helps the patients in their relaxation and stress relief journey.

4.3.1.3 Environment to patient interaction

Environment to patient interaction are mono-directional interactions from the environment to the patients, in the form of passive aural stimuli, visual stimuli or the comfortable/relaxing feeling they perceive just from being in that environment.

i. *Passive Aural stimuli* – this form of aural interaction may be in the form of background music playing in the background of the therapy. Okere (2015) explained that during the therapy, there is usually a "soft and soothing background music or a gentle instrumentals playing, which most patients perceive as soothing and induces relaxation or even sleep for the entire duration of the therapy". Other ambience sounds from the environment also contributes as "a sign of other ongoing activities from the environment or from a sound system", giving the patient a sense of company or not being alone provided it doesn't become nuisances (Okere, 2015).

ii. *Visual stimuli* – this form of visual interaction is in the form of the unique visual setting/graphic display of the reflexology environment, i.e., the way the massage room is visually organized and decorated, etc. These visual features are perceived by the patients as either being relaxing, informative or entertaining (Okere, 2015). This phenomenon can be likened to user experience (UX) or Aesthetics

The graphical representation of the multimodal interactivity in TFR presented in Okere (2015) revealed multimodal interactivity between TFR environment, practitioner and patient as shown in Figure 4.2 & 4.3. However, the proposed framework for multimodal VR-FRST would only require the interaction between two major entities which is the VR system and user as shown in Figure 4.3 & 4.4.

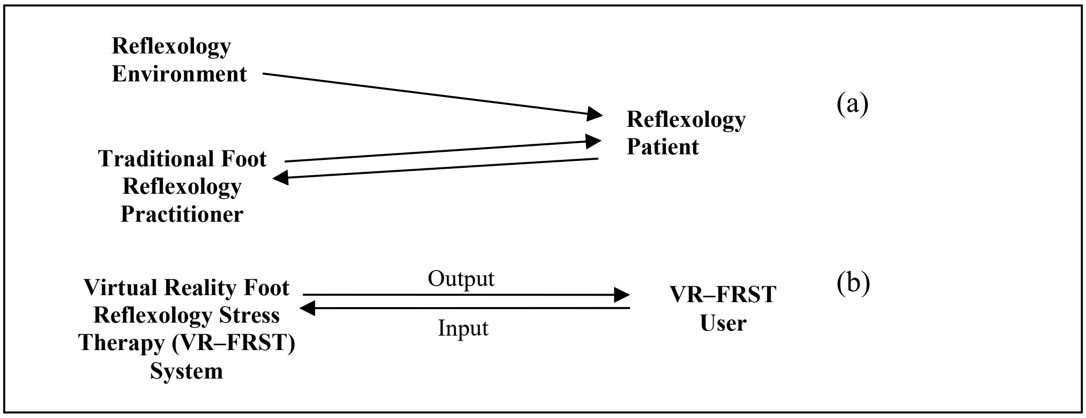


Figure 4.3. Interaction Entities in (a) TFR and (b) VR-FRST

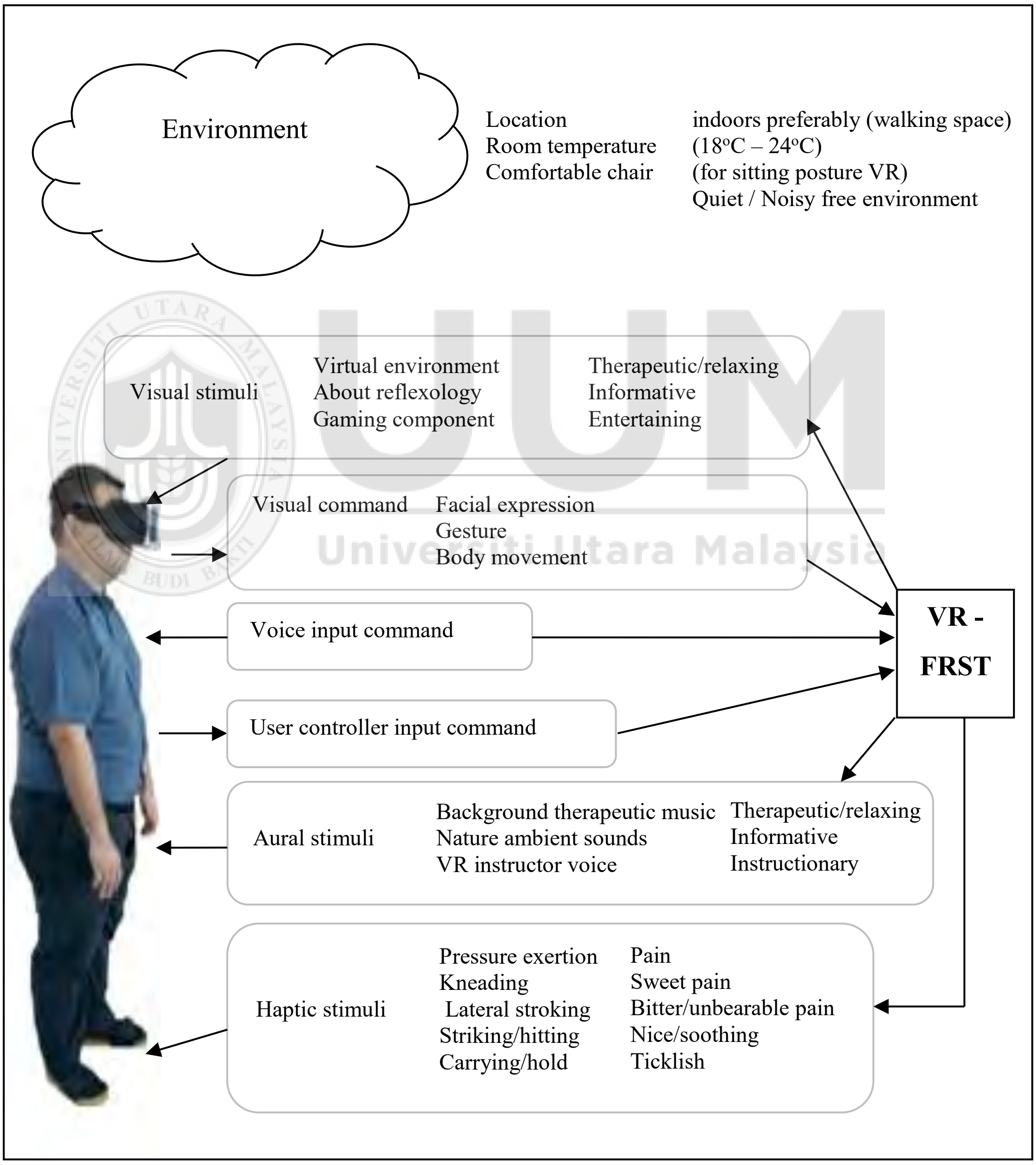


Figure 4.4. Expected Graphical representation of the multimodal interaction for VR-FRST

The VR-FRST system to VR-FRST user interaction is the interaction between the user and the VR prototype. The VR application should be used preferably indoors with walking space (for standing posture) to reduce risk of hitting an obstacle while wearing the HMD during the therapy. And for sitting posture a comfortable adjustable chair should be used to allow users relax. The external environment's room temperature should be cool within 18ºC – 24ºC, and noise free. The multimodality of the VR-Foot-ReST application allows visual, aural and haptic interaction with the VR user. The visual stimuli from the application to the user may be therapeutic/relaxing, informative, or entertaining. Visual commands that may be captured by the VR application may be in the form of facial expressions, gestures, or body movement through computer vision and capturing input devices. The aural modality in the application may allow the user to send voice input commands to the VR application to execute a particular task. Aural stimuli from the VR application to the user may be perceived by the users as therapeutic/relaxing, informative, instructionary in the form of background therapeutic music, nature ambient sounds, VR instructor voice from the VR-Foot-ReST application, received through earphones or speakers. And finally haptic stimuli by a haptic device or reflexology artifact as utilized in this research. These haptic stimuli may be in the form of pressure exertion, kneading, lateral stroking, striking/hitting, carrying/hold, and maybe perceived as painful, sweet pain, nice/soothing, ticklish, and sometimes bitter/unbearably painful (not recommended). The users are required to wear the HMD and haptic device or reflexology artifact as the system takes the users through a guided progressive relaxation and foot reflexology session. The guided progressive relaxation and foot reflexology activities is a combination of guided progressive relaxation activities and instructions given to the users to perform during the therapy session to enable users relax and relieve stress. The user being immersed in a virtual world would visually, aurally, and haptically interact with VR-Foot-ReST while wearing the RA or foot reflexology device as shown in Figure 4.4.

4.3.2 Structural or Segment Components

The proposed VR-FRST application must be organized in segment manner that ensures that users go through their relaxation journey with ease without complications arising from technicality or complexity which may deter their relaxation and stress relief. Therefore coherency and consistency is very important from start to finish in order to overcome such complication (Efendioğlu, 2012; Nurulnadwan, 2015).

Researchers (Al-Aidaroos, 2017; Ariffin & Norshuhada, 2009; Nurulnadwan, 2015) have concurred that structural components of an application comprises three segments which are: (i) Opening segment which covers the introduction and overview of the system but not the actual content, (ii) Content segment which includes the actual application content, (iii) and Closing segment which includes the ending aspect of the application. Al-Aidaroos (2017) analysed and compared the structural components of existing models and applications, and presented percentage occurence ratios of each component in both Desktop Models (DM) and Mobile Applications (MA). The table below presents the details of the structural Components and percentage ratios of existence for each component in both DMs and MAs, index composition for structural components of VR-FRST.

Table 4.3

Structural Components of existing models and index composition for structural components of VR-FRST

Section	Component	Details	% in DTs	% in MAs	Index in VR-FRST
Opening	Title	The name of the product	80%	92%	*
	Logo	A graphical symbol, sign, emblem, or design which uniquely represent the product	60%	75%	*
	Developers	List of persons and/or establishments that contributed in product development.	40%	58%	*
	Sponsors	List of official establishments that supported the product making.	0%	58%	*
	Introduction	An overview and introduction to VR-FRST application for relaxation and stress relief. Also how users should ready themselves for the therapy session	100%	83%	*
Content	Instructions	The instruction on how to ready to begin, how to commence, how to sustain and finish the therapy sessions.	100%	83%	*
	Activities/tasks	The tasks or activities that must be completed or executed during the therapy session.	100%	92%	*
	Separators	Spacers between various activities	100%	100%	*
Closing	Assistance and support	General tips, maps, and guidance to go through each phase with ease	20%	75%	*
	Thanking remarks	Appreciation for participating and completing the therapy session	20%	17%	[ ]
	Acknowledgements	Acknowledging the content contributors whom their contents were used in the product	0%	25%	*

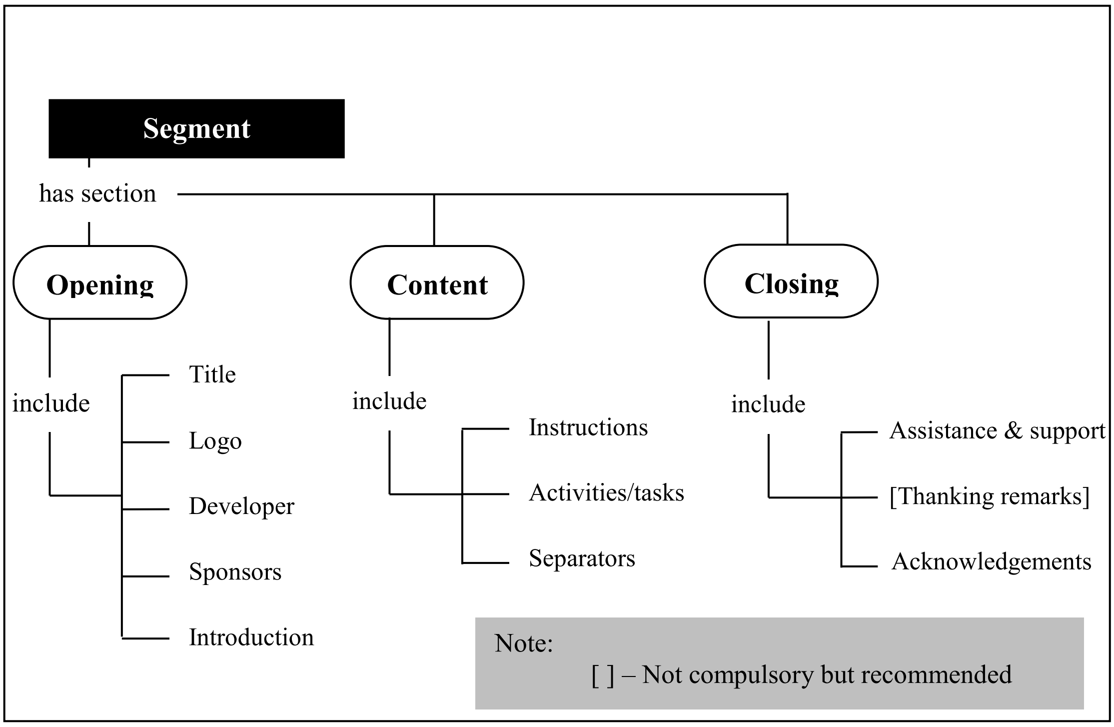


Figure 4.5. The proposed structural /Segment components of VR-FRST

4.3.3 Content Composition Component

As highlighted earlier, VR-FRST is centred on leading users towards relaxation and stress relief. Consequently, in accordance to the ABC theory which proposed that all approaches to relaxation may evoke one or more of the relaxation states (Smith et al., 2000). Therefore the content compositions of VR-FRST must contribute towards the relaxation effort, rather than deter, irritate or aggravate the users' current stress state or level. The content compositions of VR-FRST must effectively work together to evoke at least one or more of the relaxation states, and also have a positive influence on the users' predetermined stress levels.

In chapter 2, several theories, concepts and principles, in multimodality, information architecture, interaction design and design requirements were discussed, and how they contribute to the content composition of VR-FRST. VR-FRST has to have an interaction design that is able to support human communication and interaction patterns (Rogers, Sharp, & Preece, 2011; Saffer, 2010), and also similar to what is practiced traditionally (Okere, Sulaiman, Rohaya, Rambli, & Foong, 2014). Therefore in designing the content composition, this study takes into account the design and multimodal interaction architecture by the interaction entities as revealed in Figure 4.4., presented with the support of multimedia elements (Rawi, Mamat, Deris, Amin, & Rahim, 2015), presented in a selected presentation style, instruction mode and flow patterns as was also seconded by (Al-Aidaroos, 2017).

4.3.3.1 Multimodal Interaction Architecture

Dumas et al. (2009) are amongst the pioneers of multimodal interaction architecture and underlined the generic components for multimodal integration handling. These components includes: a fusion engine, a fission module, a dialog manager and a context manager, when combined are referred to as the "integration committee".

The multimodal inputs are received through *recognizers* or input devices and processors then send the input commands to the *fusion engine* for processing. The fusion engine interprets the input then communicates the result of the interpretation to the *dialogue manager*. The dialog manager receives the communicated interpretation from the fusion engine and identifies the dialog state, the transition to perform, the action to communicate to a given application, and/or the message to return through the *fission component*. The fission engine is responsible for sending feedback to the user through the most appropriate modality or combination of modalities through the multimodal synthesizers and output devices, which however depends on the user profile and usage context. Therefore, the *context manager* which is responsible for tracking the location, context and user profile, closely communicates any changes in the environment to the three other components, in order for them to adapt their interpretations as seconded by Dumas et al. (2009), and as illustrated in the Figure below.

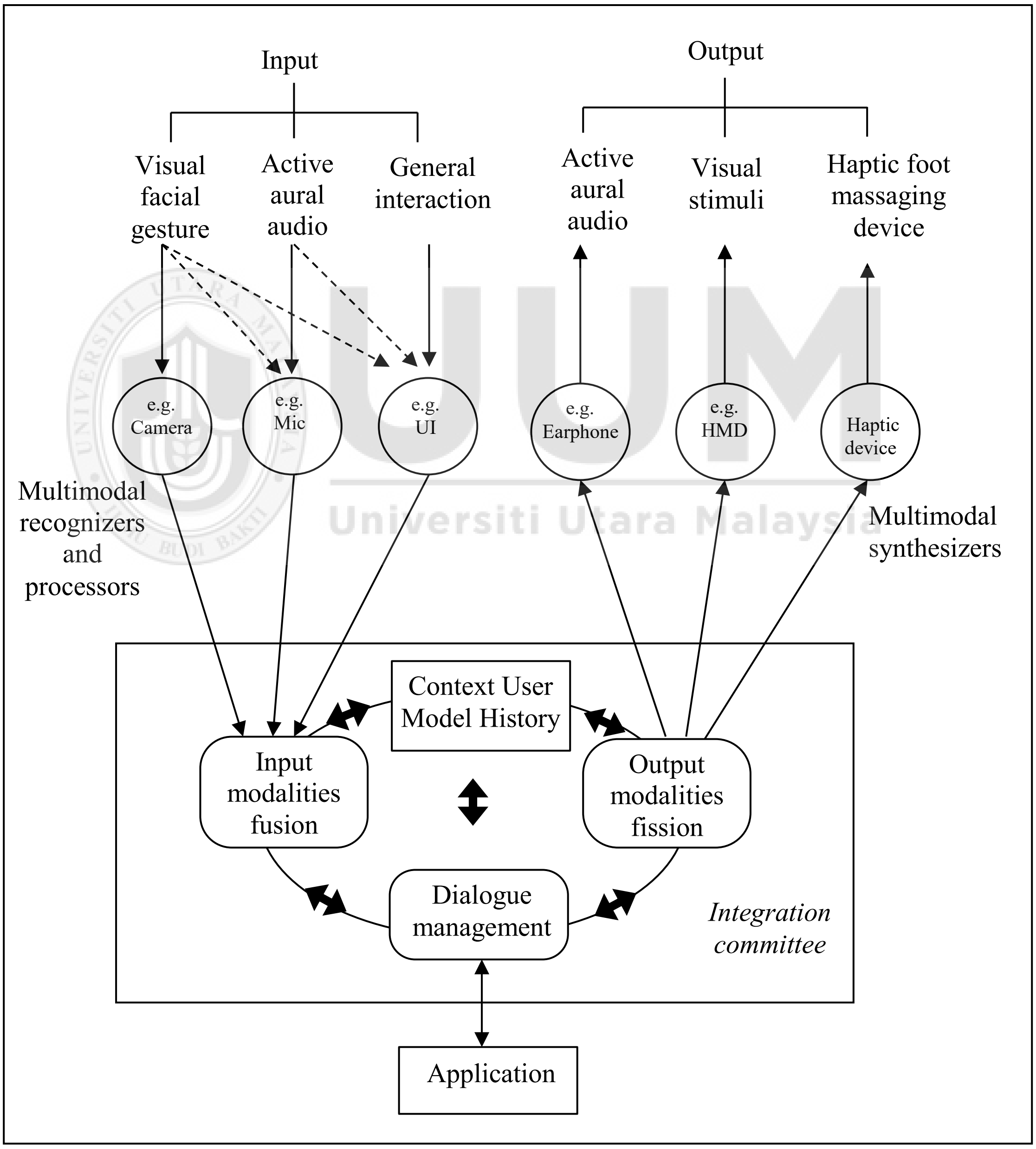


Figure 4.6. The architecture of a multimodal VR-FRST system, with the central integration committee and its major software components.

i. Organization

Generally in product development, after collecting or gathering all content that must be included in a product, proper organization is crucial in order to enable quick and easy information access and retrieval (Dillon, 2002). Content organization can be achieved by grouping similar or related content together, and categorizing these items under the same segment for easy user access and retrieval (Al-Aidaroos, 2017).

ii. Labelling

Labelling refers to naming a particular content to give it more meaning or facilitate understanding, which can either be textual (headings, hypertexts, hyperlinks, menu titles, navigation options, and index terms) or iconographic (visual icons or graphics) in nature, and are usually used in designs or in layout elements (Al-Aidaroos, 2017). These visual representations must be meaningful and based on audiences/users understanding and expectations, as some researchers would say *"a picture is worth a thousand words"* (Dansereau & Simpson, 2009; Hum et al., 2011). Hence, these labels must be clear, accurate, meaningful to users, and succinct not longer than three words (Al-Aidaroos, 2017; Wright & Jorm, 2009).

iii. Presentation Style

Presentation style is the manner with which information or knowledge is transmitted from a product to its audience/users (Al-Aidaroos, 2017). The aforementioned author highlighted that there are three (3) presentation styles which are: instruction-based, demonstration based, and documentary based presentation style. Some or all of which can be applied in an application, depending on the purpose, complexity and nature of the knowledge being delivered. In VR-FRST, all the presentation styles were applied in different section of the structural component. The documentary style was used in the opening section to introduce the therapy and all the necessary need-to-know information. The instruction style was used to instruct the users on the tasks to perform throughout the therapy session. The demonstration style was used to illustrate the actions to be performed by the users so they can follow the instructions and perform the tasks correctly.

iv. Flow Pattern

Having established that the presentation style has to do with the manner with which knowledge is delivered to the audience/users, flow pattern has to do with the flow by which the selected presentation style delivers knowledge or content to the audience/users. Content delivery can be done in two different flow pattern which are: separated and non-separated flow pattern (Al-Aidaroos, 2017). Content can be presented in the non-separated pattern when the content has to be presented steadily from start to finish in a single screen or without breakage. Separated pattern on the other hand is when fragmented contents are presented in several pages or screen. In VR-FRST, both flow patterns were utilized. The non-separated flow pattern was applied during the therapy session as the therapy needs to run from start to finish uninterruptedly. However, other aspects of the application were presented in a separated flow pattern like the opening segment is separated from the content segment. And the content segment is also separated from the closing segment. The guided progressive foot reflexology session for each foot device is different depending on the selected haptic or foot device as their nature of interactivity differ from each other. The haptic or foot device can either be electronic foot reflexology device, or reflexology artifact. In which case, transition and navigation systems need to be put in place.

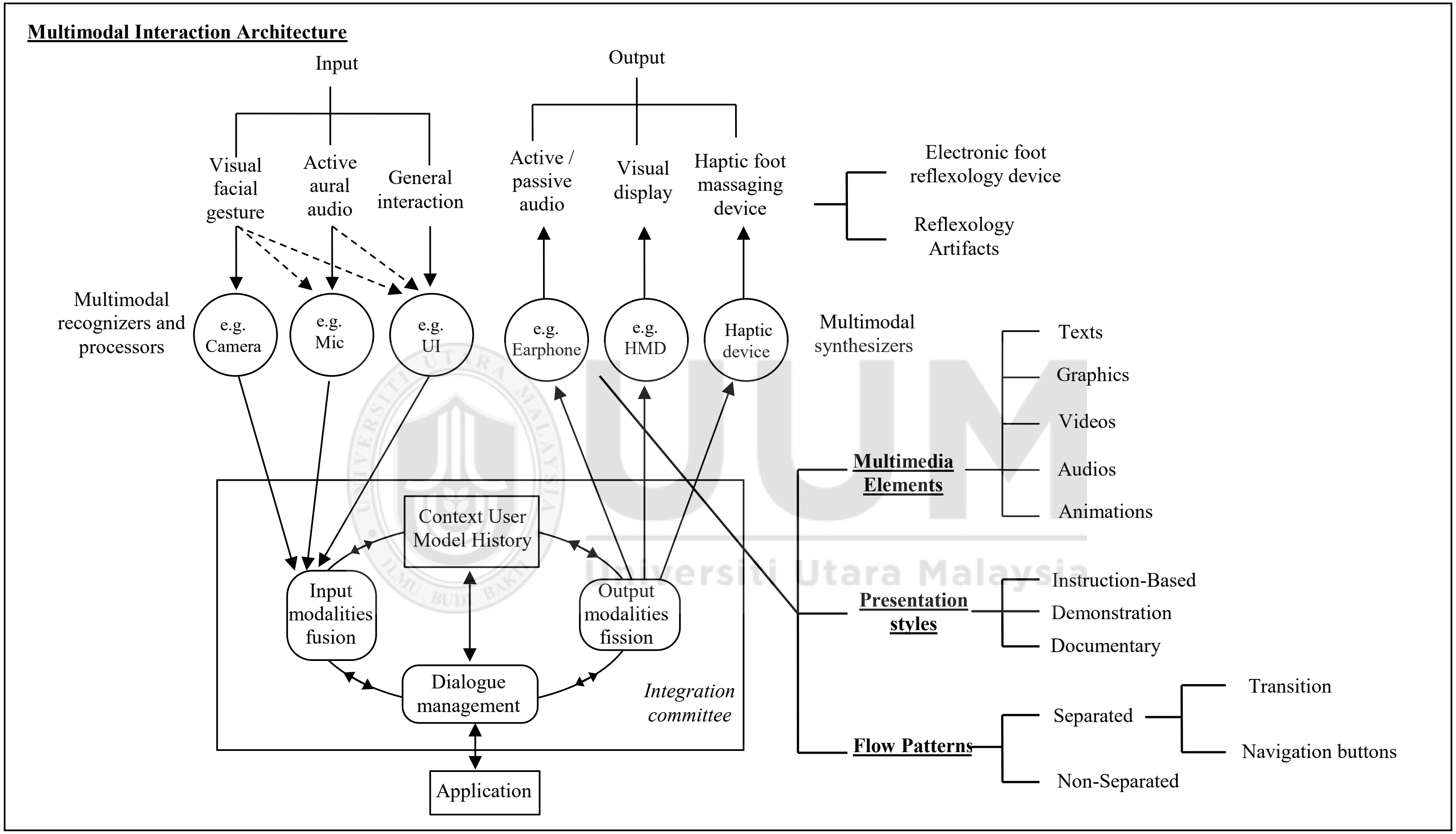


Figure 4.7. The proposed Content Composition Component for VR-FRST.

4.3.3.2 Multimedia Elements

Multimedia elements are an important component of the VR-FRST content composition. Multimedia elements can be defined as a variety of media used in presenting information to the audience including text, graphics, video, audio and animations, which all play important roles in presenting one form of information or the other to users in an interactive application (Rawi et al., 2015).

i. Text:

Texts are one of the most commonly applied multimedia elements particularly because it's the most easiest to manipulate. Nonetheless, certain guidelines have to be adhered to when applying this element such as being concise (other words, keeping it short and simple), applying appropriate readable fonts consistently with restraint (Rawi et al., 2015). In VR-FRST, texts are applied in the opening section of the application for introductory purposes, to inform the users about the necessary need-to-know of the application and the therapy as a whole. Texts were also applied in the content section as subtitles for the audio to enable users receive clarity of information during the instructionary and tasks performing phase of the therapy session. Texts were also used in the closing section for the thanking and remarks, and acknowledgement phase.

ii. Graphic

Graphical images can either be vectors or bitmaps (Rawi et al., 2015). Graphical images are applied in VR-FRST in the opening section to present the title and application logo. Graphics are also applied in the content section as navigational icons, to add emphasis, direct attention, illustrate a concept, or as background information. It is also applied in the assistance and support section of the closing phase to highlight tips, maps, and for user guidance.

iii. Video

The video element is a series of rapidly displayed images which can either be in an of analog or digital form (Rawi et al., 2015). The video element is been applied in the content section of VR-FRST combined with animation to explain certain concepts or to illustrate certain actions/tasks for users to clearly understand what is expected of them.

iv. Audio

The Audio element provides better communication quality of communication between user interfaces and users (Lopez & Romer, 2010; Rawi et al., 2015). Audio is applied in VR-FRST in every section of the application as background sound, ambience, relaxation background music, or instructional voice over during therapy.

v. Animation

Animations are series of images displayed rapidly, which creates an impression of movement (Rawi et al., 2015). Animations are applied in VR-FRST particularly in the content section, combined with video technology to present activities/tasks users have to perform during the therapy session. The usage of animation to clearly illustrate concepts is very important as sometimes it is not enough to just express ideas in texts or pictures to enable more users' engagement with the application (Rawi et al., 2015).

4.3.4 Design Principles and Guidelines

Several researches have been carried to determine design principles and guidelines for effective user interfaces or application as can be seen in (Blair-early & Zender, 2008; Eskridge, Still, & Hoffman, 2014; Gimblett & Thimbleby, 2010; Lidwell, Holden, & Butler, 2010; Nielsen et al., 1994; Niu, Yang, & Deng, 2013). The VR-FRST design principles and guidelines were constructed in line with the theories, concepts and principles of information architecture, multimodality, user interface design principles as well as design guidelines from previous studies which were all discussed in chapter 2. In line with all the aforementioned principles, a list of design principles and guidelines with justifications are listed are proposed in Table 4.5 In order to have a system that is comprehensible, controllable, meets users' needs, and above all, assist users in relaxation and stress relief.

Table 4.4

The proposed principles and guidelines for VR-FRST

	Principles	**Justification**
Multimedia Elements Design Principles		
Text	Use easy terms for readability	Clarity of instructions is very important as previous research highlighted that instructions must be clear, short and simple without complexity of understanding or blurriness. Avoid acronyms, jargons or foreign languages (Al-Aidaroos, 2017; Lidwell et al., 2010).
	Use consistent colours	Previous research highlighted that lack of colour consistency and contrast between foreground and background may cause issues in visibility and readability
	Highlight important content	Use typeface like bold, italic, underline or even colours to highlight important information that need more attention (Al-Aidaroos, 2017).

Table 4.5 continued.

Graphics	Emulate or use real-world objects or graphics.	Attaining realism or closeness to realism is the ultimate goal of any VR application to enhance realism, immersion, and the sense of real-world awareness (Al-Aidaroos, 2017; Lidwell et al., 2010).
	Use de-interlaced PNG files for bitmap/raster artwork, and JPEG for photos.	Resource constraint (small memory size) must be taken into consideration for any mobile application development (Giurgiu, Riva, Juric, Krivulev, & Alonso, 2009). PNG files supports transparency and, because it's lossless, compression artifacts don't blur important details or alter colors. Making it best for icons. Most JPEG files can be compressed without noticeable degradation of the resulting image. Even a small amount of compression can save significant disk space (Apple_Developer, 2018a).
	Use the 8-bit colour palette for PNG graphics that don't require full 24-bit colour.	The utilization of the 8-bit colour palette reduces file size without reducing image quality
	Provide simple and meaningful graphics	Make use of graphics that are clear and easy to understand, and avoiding unnecessary decorations or complex confusing graphics (Al-Aidaroos, 2017).
	Graphics should be consistent	Graphics should be aesthetically and functionally consistent. Aesthetic consistency refers to consistency of style and appearance, while Functional consistency refers to consistency of meaning and action. (For example, videocassette control symbols like for rewind, play, forward, are now adopted across devices consistently which makes new devices/applications easier to use, control and learn) (Lidwell et al., 2010).
Animations	Apply the same roles as the graphics	Use good quality animations with small file size, use simple and meaningful animation, be consistent, and only use animations when necessary (Al-Aidaroos, 2017).
	Provide appropriate movements for the animations	Use slow moving animations so that the users can catch and understand the necessary information (Al-Aidaroos, 2017).

Table 4.5 continued.

Audio	Provide clear and soothing vocalization	Vocal instructions must be delivered in a clear, short and simple manner. With a very audible pronunciation of each word(s), phrase(s) and sentence(s) for users to understand at once (Al-Aidaroos, 2017; Okere, 2015).
	Use small sized audio files.	Mobile memory is a critical resource and needs proper management. Hence, make resource files as small as possible (Cimitile & Risi, 2011).
	Use common audio coding formats (MP3).	MP3 Extension Is The Common Audio Coding Format That Is Compatible With Most Mobile Platforms. Heller (2012) concurred that MP3 files can be constructed at higher or lower bit rates, and consequently with a higher or lower ensuing quality.
	Avoid loud speaking / screaming, or rapid speaking vocalization.	Previous research highlighted that vocalization must be clear, friendly, and sudden loud sounds should be avoided as it can scare/shock users and break the flow of relaxation (Al-Aidaroos, 2017; Okere, 2015).
	Provide soothing relaxing background music and ambience sounds	Previous research highlighted that soothing or relaxing background music should provided with ambient sounds as the relaxing background music enhances relaxation and ambient sounds enhances realism (Okere, 2015).
Video	Apply the same roles as the Audio.	Use standard coding format, use small sized video, videos must be clear and precise.
	Use videos sparingly and only when necessary.	Videos are often larger in file size, and as Cimitile and Risi (2011) highlighted, memory being a critical resource for mobile phones, needs proper management. Hence, videos should be sparingly used and only when necessary.
Information Architecture Principles and Theories		
Organization	Classify content clearly	The application's content must be organized in a proper manner. The content of each section or screen must be precise, without complication of purpose (Blair-early & Zender, 2008; Rahim et al., 2013).
	Present a reasonable amount of information on each screen/display.	Present a reasonable or minimum amount of content on each screen. This can be possible through content and information fragmentation, and display on multiple screens.

Table 4.5 continued.

Labelling	Use consistent labels	Lidwell et al. (2010) regarded it as functional consistency which refers to consistency of meaning and action. Labels should reflect its content and/function. Hence, users expectations of a label's content or function, should be related or equal.
	Realize the variations of perceptions, interpretations and cultures between users.	Use terms that have unanimous interpretations across cultures. Standard labels or Universally accepted labels should be used for a resulting unanimous interpretation.
Navigation system	Basic navigations controls	Provide basic navigations (home, exit, next, back, Scroll up & down, play stop, replay) to allow users easily navigate and control the system/application.
	Clickable & Distinct	The navigation items must be designed properly in terms of clickability, shapes, dimensions and colour contrast from its background. They must be visually distinct in order to allow users to easily differentiate between navigation elements and application content (Molchanov, 2014).
	Simple and shallow	Navigations must be simple and shallow with a clear concept and the absent of unnecessary levelling through the placement of several items on menus rather that multiple level menus.
	Consistency	Asides aesthetic and functional consistency, apply internal consistency to the navigations. Internal consistency refers to consistency with between each element in a system. This allows the systems/application to be more usable and learnable when similar parts are expressed in similar ways. (Blair-early & Zender, 2008; Lidwell et al., 2010).
	Familiar and recognizable	Use familiar and recognizable navigational elements to the users to allow easy utilization and control.
	Visual cues	Use visual cues, because the human brain processes textual information much slower that visual information (Molchanov, 2014). However, they should be accompanied by assistance, help or description.
	Sticky to float	Use navigations that stick in one place, so that it does not disappear when the user scrolls up, down, left of right (Molchanov, 2014).
	Silent	Avoid playing sounds each time a navigation item is rolled over with the mouse or clicked. Users get irritated by that (Molchanov, 2014).

Table 4.5 continued.

Transitions	Apply clear transitions	Apply clear understandable transitions to notify users that the instructed task has been completed and unto the subsequent task(s).
	Each instruction should follow a transition.	VR-FootReST is designed using instruction based style. Therefore at the end of each instruction, transitions should be used to notify the end of each task.
Interactivity	Prefer direct manipulation over separate onscreen controls.	Involves interaction with objects visible in the UI and can be acted upon via physical, reversible, incremental actions that receive immediate feedback. Allow people to directly interact with virtual objects using standard interactions or familiar gestures. In other words, keep interactions simple (Frohlich, 1997; Sherugar & Budiu, 2016).
	Support both information seeking and relaxed exploration.	Allow users to reset the experience if it doesn't meet their expectations. Don't force people to wait for conditions to improve or struggle with object placement. Studies show that some categories of users who do not like to have the option to change the flow of a running program; they just prefer to watch passively. This is very much desired in this case of relaxation therapy for an uninterrupted flow in the therapy process for maximum therapeutic experience. Still, there might be cases in which the addition of interactive elements enhances the entertainment experience (Malone, 1982). Chorianopoulos (2008) explained that, interactivity should not be enforced to the users, but should be always pervasive for changing the flow of the running program.
	Always give users status update, guidance, and provide clear feedback on each user action.	Guidance and feedback is another concept connected to interactivity (Domagk, Schwartz, & Plass, 2010). Guidance aims at directing cognitive processes of the learner such as generating hypotheses, monitoring, and structuring the overall process. Feedback provides response or output to user actions (for instance, providing the correct answer with or without elaboration or requiring the learner to keep trying until he or she gives the correct answer) (Domagk et al., 2010)

Table 4.5 continued.

TFR User Requirements		
Multiple relaxing scenery	Provide pressure exertion regulation and variation	Previous research highlighted that several users should be allowed to regulate how much pressure exertion and pain they can bear (Okere, 2015).
Visual information about the therapy	In the introduction section, provide visual information about the therapy like FR charts, FR artifacts (RA) and so on.	Previous research highlighted that application should offer informative visual display for users to explore (Okere, 2015).
Seen or unseen instructor	Users should have a choice of seen or hidden instructor	Previous research highlighted that users should have the option to see or not to see the instructor (Al-Aidaroos, 2017; Lindner et al., 2017; Okere, 2015).
Instructor/system recommendations Before therapy	Environment temperature between 18 to 24ºC	Recommend user to conduct therapy session in an environment with (18 to 24ºC), Individual preferences will vary, so find the temperature best suited for you. Studies have shown that temperatures that fall too far below or above the range of (75 degrees Fahrenheit and below 54 degrees) can lead to restlessness, but within the range can help facilitate the decrease in core body temperature from the normal wakefulness temperature of (98.6 degrees Fahrenheit) that in turn initiates Relaxation States like sleepiness (Mercola, 2009; National-Sleep-Foundation, 2018; Phillips, 2015).
	Noise free background	Recommend users (especially Non-headphone Users) to conduct therapy session in a noise free environment as background noise will interfere with the therapy making instructions not clear enough, and even more, interfere with the relaxation process (Okere, 2015).
	Health concerns	Discourage patients with conditions like early pregnancy, cardiovascular disorders, oedema, diarrhoea, diabetes, recent surgery, arthritis, cancer, bleeding disorders or on anticoagulant therapy, where there is a tendency for easy bruising / bleeding, as it may aggravate their health conditions like spread of cancer cells (Hope-Spencer, 1999; Ingham, 1984; Ministry-of-Health-Malaysia, 2011).
User Interface and Layout		

Table 4.5 continued.

	Use optimal screen dimension and resolution	Screen dimensions and resolution for different mobile devices differ from each other. This implies that user interfaces must be designed to adapt to all devices' screens (Cimitile & Risi, 2011). This also affects the efficiency and effectiveness of the participants' completion of the required tasks, as well as their satisfaction, compatibility, and enjoyment of the undertakings (Motamedi & Choe, 2015).
	Memory conservation	Memory is a critical resource which changes dependently from device capability. Overall application's memory footprint should be as small as possible by eliminating memory leaks, discarding unnecessary resource files, making resource files as small as possible, and loading resources lazily (Cimitile & Risi, 2011).
User Interface & Layout	Allow user interface personalization and user interaction control	Interface personalization should be available to users. This allows users to increase productivity and have a more convenient interaction with the system/application (Stadler & Lorenz, 2008).
	Build on prior knowledge & Use intuitive design	Apply concepts and techniques being utilized in similar tasks, as it allows users to use intuition and prior knowledge to interact, realizing the appropriate action to be taken with an object at 1st glance (Al-Aidaroos, 2017).
	Provide proactive assistance	Applications should be capable of improving users' capabilities and guide them to become independent users. This allows users to complete their tasks easier and more efficiently (Kamper, 1999).
	Minimize users' error potential	As relaxation and stress relief is the ultimate goal. Use non-complicated designs which allow users to cruise through each element, interaction and tasks with ease at 1st try.
	Support alternate selected haptic technology	Support application of alternate foot device (RA or electronic).

Table 4.2 and Figure 4.11 presents the initial proposed principles and guidelines for VR-FRST which encompasses multimedia elements design principles, information architecture principles and theories, TFR user requirements, and user interface and layout. The next phase discusses technologies and developmental process involved

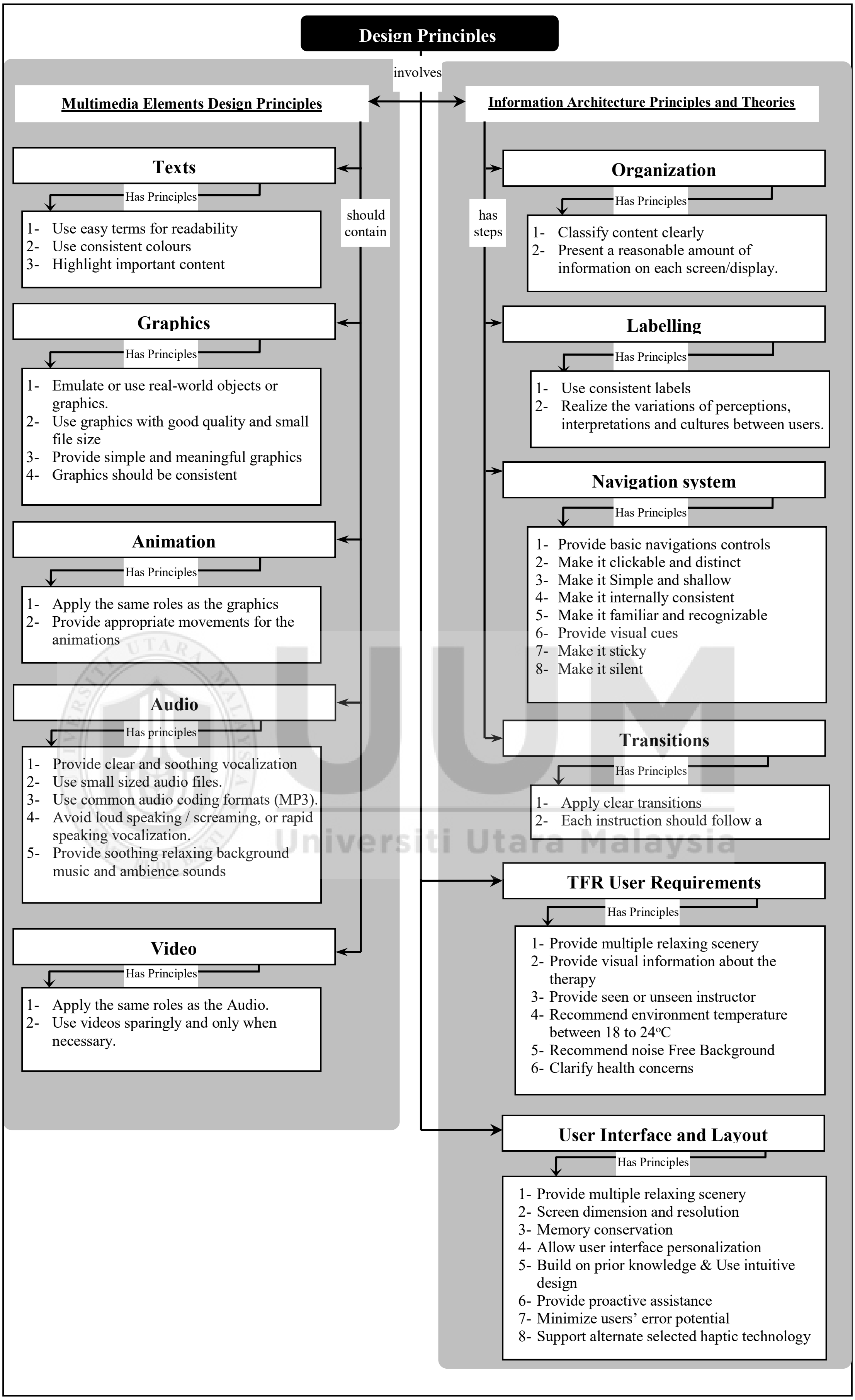


Figure 4.8. The proposed Design Principles and Guidelines

4.3.5 Technologies

Technology here refers to the platform on which the VR application operates. Recently, due to the computational power and portability of mobile devices, people prefer to perform their tasks/works using their mobile devices (Al-Aidaroos, 2017), which revealed that 6.7% of the respondents preferred using computers to perform their tasks, while 93.3% preferred their portable devices. Besides, accessibility to certified reflexologist were amongst the challenges TFR possessed unlike RA (Okere et al., 2015); mobile devices offer the ultimate accessibility (whenever, wherever).

Majority of VR systems/applications that are currently available require a personal computer or console to power them (Chang, Hsu, Hsu, & Chen, 2016; Kuchera, 2016). Chang et al. (2016) and Kuchera (2016) highlighted that VR technologies can be categorized based on the display being used by the device into two (2): Mobile phone and Desktop/console (integrated). Also Common devices within the mobile platform includes (Google Cardboard, Samsung Gear VR), while within the integrated platform of desktop/console include (Oculus Rift, HTC Vive, PlayStation VR). Some other technology which may be electronic or non-electronic in nature, though categorized under technology are neither in the category of mobile VR or console VR, nor are they a VR technology, but are categorized as stand alone. These may include electronic FR devices or reflexology artifacts like reflexology slippers, reflexology pebbles. Figure 4.9 presents the initial proposed multimodal interaction framework for virtual reality foot reflexology stress therapy which generally consist of (i) design principles (ii) content composition components (iii) structural components (iv) technology.

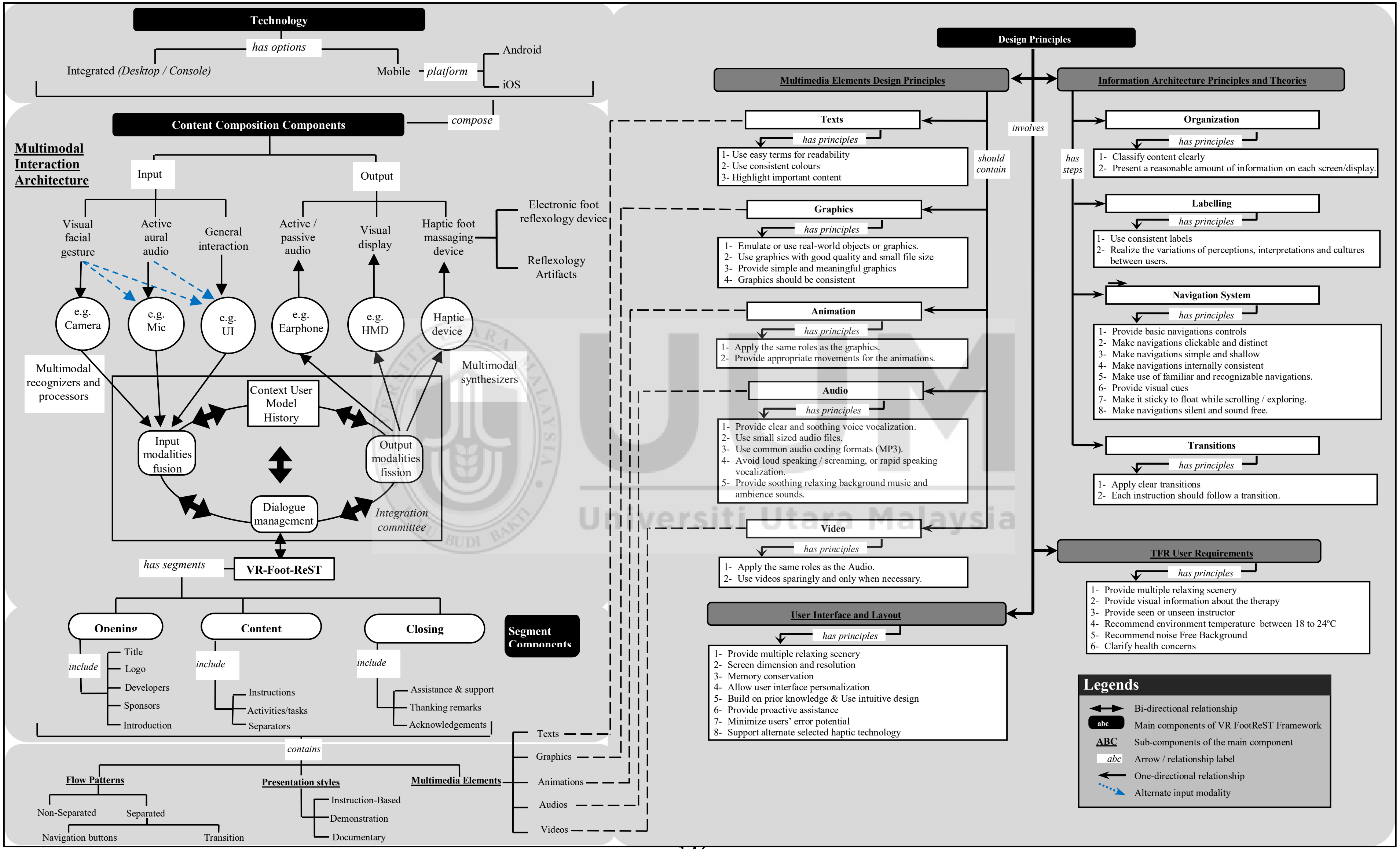


Figure 4.9. Initial proposed Integrated Multimodal Interaction Framework for Virtual Reality Foot Reflexology Stress Therapy Application.

4.4 Framework Validation

Expert reviews is a recognized and accepted technique for product quality improvement (Radice, 2001; Wiegers, 2002). This is as a result of the effectiveness and cost-efficiency of the technique in revealing challenges, issues, and problems with the existing deliverables, design, framework, or document. This expert review method requires the utilization of the evaluators' expertise, experience and knowledge to impact and influence the evaluation results. Hence, the study employs experts that are either in Human Computer Interaction (HCI) or Multimedia or Mobile Applications or Virtual Reality (VR) or Information Systems (IS) or Computer Science (CS) and/or related areas to evaluate and enhance the proposed framework. And have been teaching / researching in VR or Multimedia or HCI or interaction designs or IT and/or CS areas for at least five (5) years.

Based on those criteria, about 20 invitations were sent out to experts to participate in the expert review study. However, only 7 experts accepted and responded to the review. In line with researchers, five (5) experts are typically sufficient to identify over 75% of the issues, shortcomings and challenges of a system (Rogers et al., 2011; Tory & Möller, 2005). Consistent to that, Shneiderman and colleagues confirmed that between 3 to 5 experts are sufficient in an experts review (Shneiderman et al., 2016). Based on these recommendations, the study employed 7 experts to participate in the evaluation and enhancement of the proposed Integrated Multimodal Interaction Framework for Virtual Reality Foot Reflexology Stress Therapy (VR-FRST). The experts demographic profiles are presented in Table 4.5

Table 4.5

Review experts' demographic profile

No.	Gender	Education	Occupation	Field of Expertise	Yrs of Exp.	Affiliations
1	Male	PhD	Lecturer	Virtual Reality, Cognitive Linguistics, and TESL	12	Universiti Malaysia Sarawak
2	Male	Master	Researcher	HCI, Artificial Intelligence, intelligent System	7	Universiti Malaysia Sarawak
3	Male	PhD	Senior Lecturer	Software Engineering, Creative Multimedia Innovation, Information Technology	12	Universiti Utara Malaysia
4	Female	Master	Lecturer	Human Computer Interaction (HCI), Online Visual Communication, Persuasion	15	Universiti Utara Malaysia
5	Male	PhD	Senior Lecturer	Folk literature classification, Multimedia application	16	Universiti Utara Malaysia
6	Male	PhD	Lecturer and researcher	HCI, Usability, User Centered Design	7	Augustine University Ilara Epe Lagos, Nigeria.
7	Male	PhD	Lecturer and researcher	HCI, Software Engineering	10	Koya University, Koya, Kurdistan Region of Iraq

4.4.1 Review Instrument and Procedures

The expert review process is aimed at evaluating and validating the proposed Multimodal Interaction Framework for Virtual Reality Foot Reflexology Stress Therapy (VR-FRST). Hence, electronic mail (e-mails) was used to communicate with these experts. First an invitation or request email was sent to a list of experts with an online consent form attached as a link in the email (as shown in Appendix E). The invitation is considered accepted when the online consent form is filled and submitted. Consequently, the proposed integrated multimodal interaction framework for VR foot reflexology stress therapy as shown in 4.9, is attached to a second acknowledgement email, and a link to the online evaluation instrument as shown in

Appendix E. A considerable amount of time was allocated each expert (2 weeks) to complete the review and submit their review feedbacks. After which a remainder email is then sent after every subsequent week to remind the reviewers to review and return their feedbacks to the researcher. The experts took about 3 to 4 weeks to complete their review process and the return to the researcher.

The instrument used for the expert review was adapted from Tosho (2016), Nurulnadwan (2015), Siti Mahfufah (2011), Al-Aidaroos (2017). The review instrument consist of five major questions which assesses: (1) the relevancy of the proposed elements, (2) the understandability of the proposed design principles, (3) the clarity of the terminology used, (4) the elements flows and connection logicality, (5) the readability of the proposed framework. These are accompanied by a few demographic inquiries such as education level, field of expertise, affiliation, and years of experience. For each question in each section, experts were given the alternative to comment or critique each aspect of the framework. Every component in the proposed framework were outlined in the instrument and the experts were required to verify the relevancy, understandability or clarity of the elements of each component by selecting either: (1) All are relevant, (2) Some are relevant, (3) Some are definitely not relevant/ leave a comment (to allow experts to share any recommendation, critique, issue, confusion, concerns, or suggestion for each component). And in the final section, experts were expected to use their experiences, expertise, intuition, and knowledge to give additional views or further comments on the proposed framework. The following sub-section elaborates on the expert review findings.

4.4.2 Expert Review Findings

Based on the expert review feedbacks that was received from the experts, the review feedback are presented or tabulated in Tables 4.6 and Tables 4.7 below, to buttress a clear illustration showing the different response frequencies.

Table 4.6

Response Frequencies and Review feedbacks from experts review

Items	*frequency (n=7)*		
	All are relevant	**Some may not be relevant**	**Some are definitely not relevant/Leave comment**
1. The proposed elements in the following components are relevant.			
a. Technology	3	1	**3** - The haptic foot massaging device, is it also under the integrated or console platform? if no, please make provision for it in the technology section. - Desktop as in Windows? How about Mac's environment? What does console refer to? Gaming console or...? - Can consider including "Standalone" technology.
b. Content composition	6	1	**0** ---
c. Segment composition	6	0	**1** - What about "Gamified Elements" in Presentation styles, which is largely the beauty of incorporating VR.
d. Design Principles	3	1	**3** - Is graphics a multimedia element? Do you mean image? Please confirm. - All are relevant, but they should be captured under one (or more) known design principle -to which the elements (like text, graphics, etc) can lay claim to. For example, is Shneiderman's user interface design principle applicable, or is it Cooper's interaction framework for the multimedia element design. - The MMEDP's details could be more specific.
	It's easy to understand	**Needs some explanation**	**Needs very detailed explanation / Leave comment**
2. The proposed design principles are easy to understand.			
a. Multimedia Elements Design Principles	6	0	**1** - Suggestion: include Interaction element since it's a core binding element for interactive multimedia product
i. Texts	5	0	**2** - Suggested to add maximum number of prominent colour usage in one design. - Easy terms like what?; consistent colour without any reckon to colour type and class?; and how is important

Table 4.6 Cont.

					content is expected to be highlighted: with colour or text font size or alignment.
ii.	Graphic	5	0	**2**	- What do you mean by consistency in graphic? Probably you can mention the two major categories: bitmap vs. vector - Good quality in range of what and what pixels, or frame size;
iii.	Animation	4	1	**2**	- What is an appropriate movement for an animation? Could be clarified. - What is the appropriate movement, per second, etc.
iv.	Audio	6	0	**1**	- Small size of what size range
v.	Video	5	1	**1**	- Size of video? Format of video whichis appropriate for the said purpose?
b.	Information Architecture Principles and Theories	6	1	**0**	---
i.	Organization	7	0	**0**	---
ii.	Labelling	6	1	**0**	---
iii.	Navigation system	6	1	**0**	---
iv.	Transition	6	1	**0**	---
c.	User Interface & Layout	5	1	**1**	- Why is the 1st guideline a replica of TFR user requirements' 1st guideline? I think it should be excluded from this segment
d.	TFR User Requirements	5	1	**1**	- What is TFR? please write in full or include in Legend

		It's easy to understand	**Needs some explanation**		**Needs very detailed explanation / Leave comment**
3. The following terminologies in the proposed framework are easy to understand.					
a.	Multimodal interaction	6	1	**0**	---
b.	Integrated Platform / Console	4	1	**2**	- Options for technology are divided into Integrated or mobile? But there's also integrated platform for mobile. - Desktop is the targeted platform? Define console
c.	Multimodal recognizers	5	1	**1**	- A bit difficult to differentiate as recognizers and synthesizers are inline
d.	Multimodal Synthesizers	4	3	**0**	---
e.	Fussion	5	1	**1**	- Fussion or Fusion

Table 4.6 Cont.

f.	Fission	6	1	**0**	---
g.	Labelling	6	1	**0**	---
	Select (Yes / No)	**Yes**			**No / Leave comment**
4.	The connections and flows of all components are logical	6	1		- The connections are OK, but the sentences don't show clear relation to any component
5.	Overall, the multimodal interaction framework is readable	5	2		- I want to see the relation for the definitions in sentences describing the terms use relation to any component - For a framework, it is readable but the details of the MME Design Principles could be more specific

As presented in Table 4.6 most of the experts concurred that each component in the framework is relevant expect for Technology, Segment composition and Design principles components which had some recommendation, critique, or suggestion from the experts that needs to be addressed. In terms of understandability, most experts agree that the multimedia element design principles are easy to understand, however, with a few concerns raised that require detailed explanation. All the experts concur that the Information Architecture Principles and Theories easy to understand. However, some concerns were raised on the User Interface & Layout, and TFR User Requirements which require some explanation and clarification. In addition to that, the majority of the experts concur that all the terminologies used are easy to understand, with a few concerns raised by the experts on component like the Integrated Platform / Console, Multimodal recognizers, and Fussion, which need some clarification. Finally, the majority of the experts concurred that the flow of connection of all components are logical, and the overall framework is readable; with a few recommendations that need to be addressed. Table 4.7 consequently presents further remarks from the expert reviews which contain each expert’s subjective opinions and comments to be used to revise and enhance the proposed framework.

Table 4.7

Further remarks from the expert reviews

Expert ID	Experts Subjective Opinions / comments
R1	- The haptic foot massaging device, is it also under the integrated or console platform? if no, please make provision for it in the technology section. - Is graphics a multimedia element? Do you mean image? Please confirm. - What is TFR? Please write in full or include in Legend.
R2	- The basic Framework Hierarchy is good, but provides the relation or where Definition of Terms is used, so that is easier to understand.
R3	- It is good if the researcher can provide more details for the introduction. For example, is the app is a web-based type of app? Is the framework will be generalized or more specified to certain platform/device? If it will be generalized, the UI & layout segment should provide more info on the approach that will be used for managing multiple layout settings. How is this VR-FRST works? As a tutorial app or presentation layer installed to a foot reflexology machine? BTW, what is TFR ?
R4	---
R5	1. The arrow lines in the framework have different thickness levels and this is not captured in the legend. 2. Dotted arrows that connect the multimedia elements with the design principles are not captured in the legend. 3. Established design principle(s) that mostly captured your intent in the design elements should be named.
R6	Could help if the model is more dynamic than linear, as in there is an indicator that a developer or designer can begin referring to your framework from any elements they wish to begin instead of being confined to the linear flow.
R7	1. What is TFR? Please write in full or add in Legend. 2. Multimodal synthesizers and recognizes are they the same? if they are not, please do distinguish. 3. VR-Foot-ReST or VR-FRST is it the application or domain? Do revisit. 4. Usage Context is missing from your model. i.e. how, when and where the application can be applied. 5. Is reflexology artifact like slipper also under console and mobile technology? Please revisit and make room for non-electronic device / tool 6. I don't think you need to include "has principles" under every design principle element. We already know it’s the principle under the element. You may exclude it to make your framework less complex or better still make room to add content in your final framework.

4.5 Analysis Discussion and Review modifications

The experts' review feedbacks, recommendations, critics and suggestions were grouped into categories and tabulated as shown in Appendix C. These were then utilized to create review modifications based on the experts' recommendations and justification from literature, also shown in Appendix C. This review modifications were then implemented into the final framework as presented in Figure 4.12.

4.5.1 Technology

The experts demonstrated the unclear presentation of the technology component of the framework. Hence, the technology element was restructured following the recommendations of (Angkananon et al., 2013b, 2013c; Burden, 2016). This made provision for every form of technology that is involved in the technology component of the framework as shown in Figure 4.10, which addresses all the concerns raised by the expert reviewers. The elements in the technology component may be electronic or non-electronic. The electronic device may be in the form of mobile (android and iOS platform), Integrated (Desktop / Console), or stand alone as is the case for electronic foot reflexology massage device. The non-electronic devices may be in the form of reflexology artifacts (like reflexology slippers or pebbles) which may now be deployed alongside mobile VR, or used as a standalone

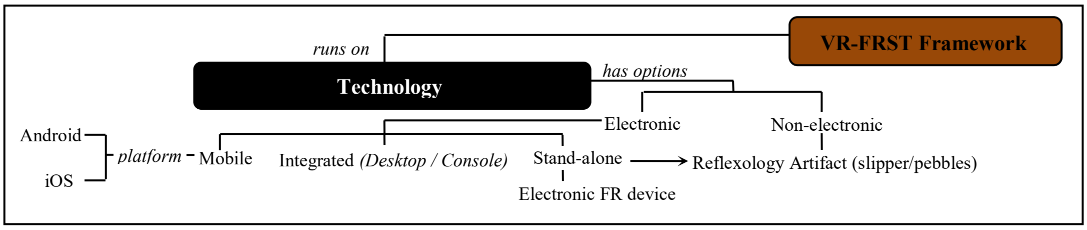


Figure 4.10. The technology component of the multimodal interaction VR-FRST framework

4.5.2 Content Composition

The experts demonstrated the unclear difference of the multimodal recognizers and synthesizers in the framework. This was addressed by distinguishing the synthesizers and recognizers through grouping each category in a doted white rounded square. Experts also recommended that the appropriate spelling for the terminology “Fusion” be verified. This was addressed consistent to Dumas et al.'s (2009) multimodal interaction architecture.

The elements in the content composition component of the framework are categorized within the input, output, or integration committee. From the input category, users may send multimodal input commands into the VR system via visual gesture captured though computer vision like camera; active aural, voice or sound input command and captured through a mic; and general interaction captured through user interfaces, remote controllers, joysticks or any other devices. In certain cases, the exact same command input command may sent through alternative input modality (for instance, the voice input command "stop" inputed through a mic, may also be inputed by pushing the stop button on a remote controller. These input devices are called multimodal recognizers and processor (Dumas et al., 2009). From the output category, users may receive multimodal output or feedback from the VR system via active or passive audio from an output device like earphones; visual display from a visual output device like a HMD or screen; or haptic feedback from a haptic foot massaging device. These output devices are called multimodal synthesizers.

From the integration committee category, the multimodal-recognizers capture the input commands and send the results to the fusion engine for interpretation. Following the interpretation completion by the fusion engine, the interpretation is sent to the dialogue manager. This dialogue manager is responsible for identifying the dialog state, the transition to be performed, the action to be sent to a given application, and the feedback to be sent through the fission component. Following the interpretation completion by the fusion engine, the interpretation is sent to the dialogue manager. This dialogue manager is responsible for identifying the dialog state, transition to be performed, and action to be sent to a given application, and/or the feedback to be sent through the fission component. The fission engine outputs feedback to the users via the most appropriate modality(s) based on the user profile and usage context. The content composition component is presented in Figure 4.11.

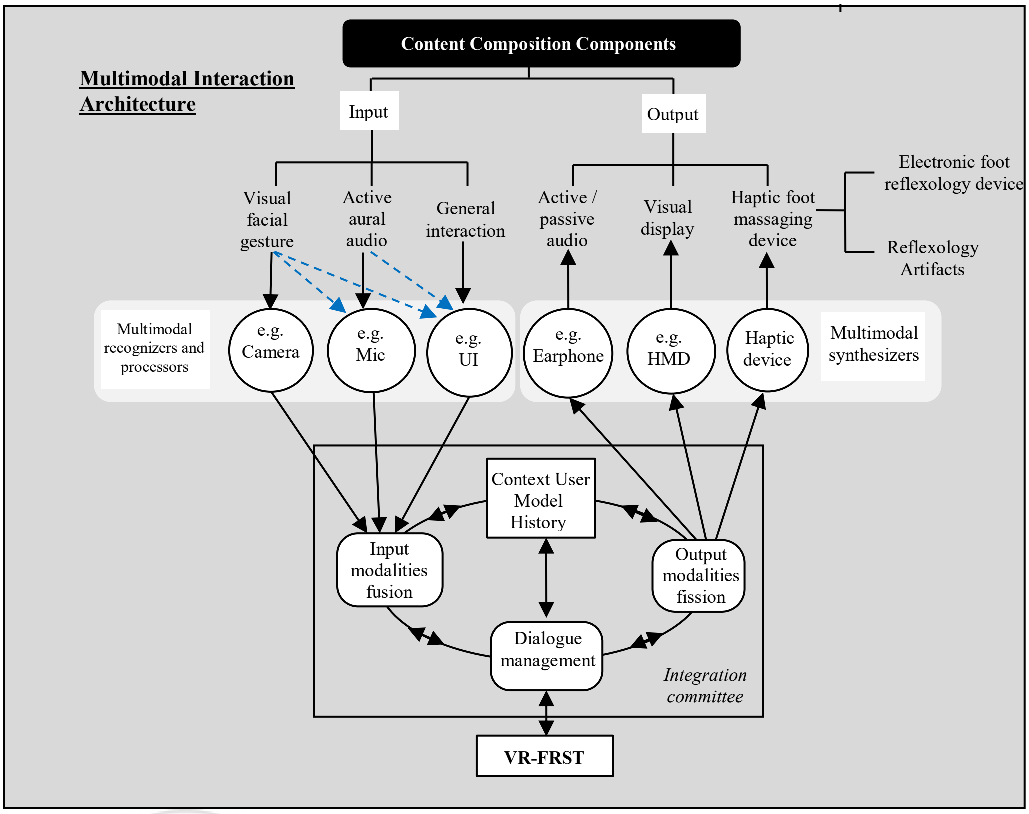


Figure 4.11. Content composition component

4.5.3 Segment Composition

Smith et al. (2000) expressed that every type or approach to relaxation entails sustaining passive simple focus, which is the opposite of discursive effort. People generally strive in everyday life, and our attention shifts discursively and digressing from complex topic to topic. Conversely, we let go in relaxation, and we focus on just one simple thing (relaxation stimuli). Gamification entail increasing brain activity which may include cognitive process, working memory and so on (Howard-Jones, Jay, Mason, & Jones, 2016).This contradicts the overall target of the therapy which aims at sustaining attention while reducing overt behaviour and covert or cognitive activity (Smith et al., 2000). Hence, gamification is excluded from the framework.

4.5.4 Design Principles

The design principles outlined in the framework was motivated by several prominent researchers like Norman, Nielson and Molich, Shneiderman and Plaisant amongst others with justifications. However, Alan Cooper deals with the interaction design between people technology and business and the development approaches and development team. This is not the focus of the framework; hence Alan Cooper's "About face interaction design" was not included.

4.5.5 Multimedia Elements Design Principles

Interactivity was included in the design principle as a binding component of multimedia products. Graphic is an established multimedia element, though sometimes referred to as graphical images (Rawi et al., 2015).

Experts requested the clarification of "appropriate movement of animation". The principle was paraphrased for clarity purpose to "Animation actions must match audio output corresponding to user goals" (synchronized).

Experts raised the concern of "use small size of what size range". The principle "use small sized audio file" was removed as focus is allocated to the file codec and compatibility (MP3). MP3 files are generally compatible and have small file sizes.

In addressing this concern raised by the experts. The principle "Use common video codec (MP4)" was added to the design principles for video. The Mp4 video format is an ISO Base Media File Format (Amon, Rathgen, & Singer, 2007).

4.5.6 User Interface & Layout

This principle "provide multiple relaxing sceneries" was excluded from the User interface and Layout segment as it is a replica of the 1st principle in the TFR User requirement segment.

4.5.7 TFR User Requirements

TFR is an acronym for the terminology Traditional Foot Reflexology. The acronym was removed from the framework and replaced by the full terminology "Traditional Foot Reflexology".

4.5.8 Overall Framework

Relation definition was outlined in the legend, highlighting each relation and its interpretation or meaning. Figure 4.12 presents the final integrated multimodal interaction framework for virtual reality foot reflexology stress therapy application.

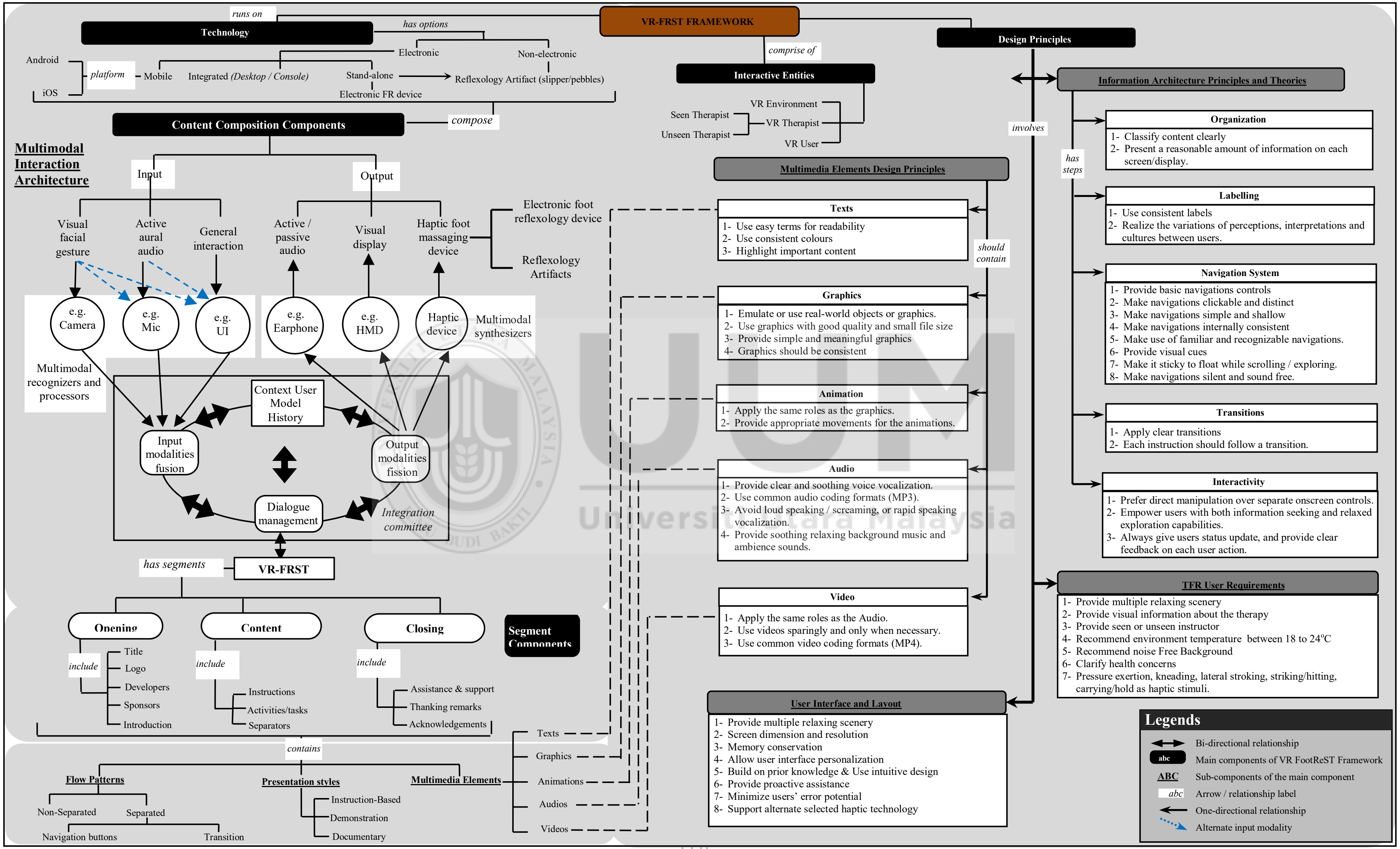


Figure 4.12. Final Integrated Multimodal Interaction Framework for Virtual Reality Foot Reflexology Stress Therapy Application.

CHAPTER FIVE
PROTOTYPE DEVELOPMENT AND EVALUATION FOR RELAXATION AND STRESS RELIEF

5.1 Introduction

This chapter discusses the design and development of virtual reality foot reflexology application prototype. The chapter also presents the demonstration of the prototype with medical and complementary therapy experts to prove that the idea works, and provided feedbacks on the effectiveness, safety, and features of the prototype.

5.2 VR-Foot-ReST Prototype Development

The development method of this project utilized the prototyping approach as adapted from (Laudon & Laudon, 2009). This approach involves three stages which include developing initial proto-type, using prototype, and revising and enhancing prototype as outlined in section 3.3.3.2. VR-Foot-ReST is an acronym for Virtual Reality Foot Reflexology Stress Therapy Application. This application was developed using Unity 3D for Android Smartphone. After publishing into Android APK, the APK is installed and ran in an Android smartphone for testing. C# programming language was used to write the codes and scripting while the Unity environment was used to design the interface of the proposed VR-Foot-ReST application. Photoshop 7 (Image Processing Program) was used to create and modify the required images, photos and icons. Audacity 2.0 (An open source Digital Audio Editor) was used to record and edit the required audios. These audio files were exported into MP3 format for size portability and compatibility in Unity 3D. Finally, Adobe Premier Pro was used to design and edit all the required videos and published into MP4 for size and graphic compatibility in Unity 3D.

5.2.1 Developing Initial Prototype

All the requirements needed for the development of the prototype were gathered, the contents that were included in the prototype application were prepared, and the prototype was subsequently developed. The Unity3D game engine environment was used for prototype development. The prepared contents were imported into the Unity 3D asset folder, and the initial version of the prototype was developed. The APK was exported and installed unto an Android platform. The Android mobile phone HMD (Samsung VR Gear) as shown in Figure 5.1 was selected because of the added functionalities it provides. Table 5.1 presents the input / output devices and functionalities.

Figure 5.1. 360º front view of waterfall outdoor relaxing VR environment

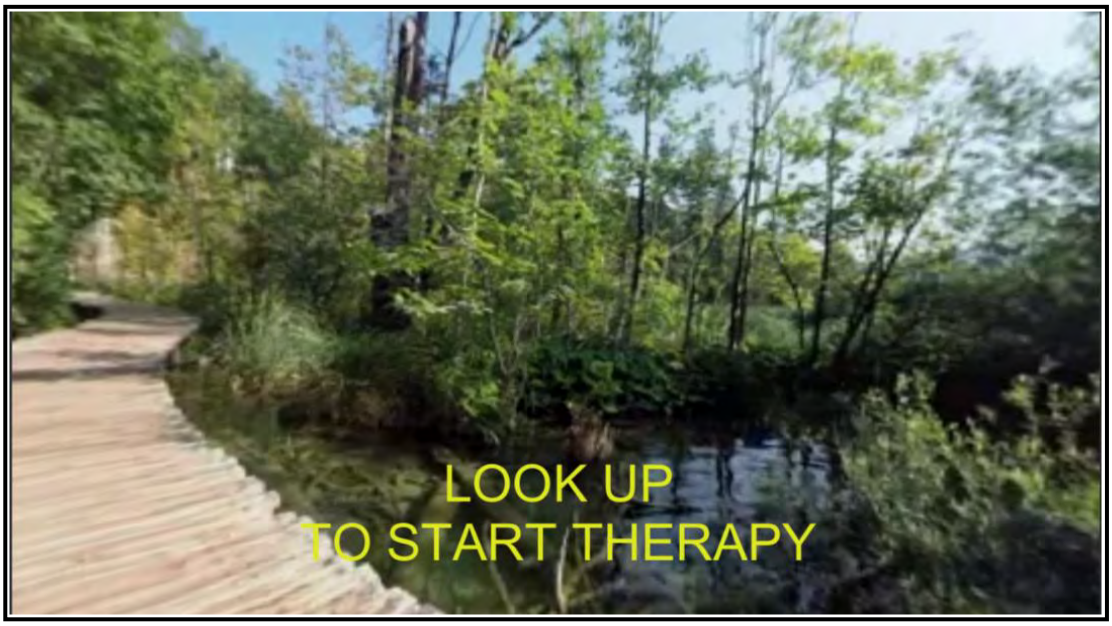


Figure 5.2. 360º rear view of waterfall outdoor relaxing VR environment

Figure 5.3. 360º view of after therapy congratulatory message

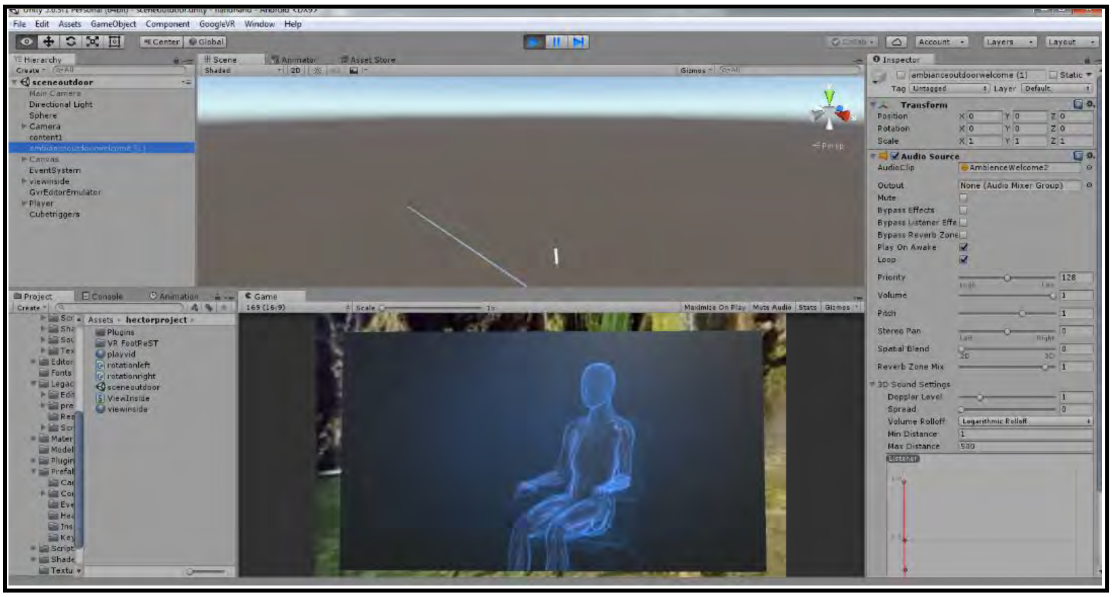


Figure 5.4. Unity3D Game development environment

Figure 5.5. VR-Foot-ReST components of Mobile VR HMD with Bluetooth Gamepad Remote Controller, Reflexology Slipper (RA) and JBL Bluetooth

Table 5.1

Input / output devices and functions

O/I device	Function
In-built Mic	Voice input command
JBL Bluetooth earphones	The JBL Bluetooth earphone is designed for noise cancellation and adaptive Noise control
Mobile In-built screens/Monitor	For visual display of VR environment
Reflexology slippers	For Haptic interaction and foot reflex point activation. Versatile and Multipurpose Massage Slippers Smart design Simple and easy to use Effortlessly working Amazingly inexpensive Works by acupressure that helps to stimulate the vital points of the body Helps to minimize the level of tension, stress and tension Improve the symptoms of neck, back and shoulder pain Helps to relieve fatigue and improves the circulation of blood Helps to maintain health by removing the internal harmful chemicals and toxins of the body Prevents illness Helps in the development of vestige organ Prevents the ageing process Helps invigorate the cellular vitality Prevents leg cramps Helps to recover lethargy Absolutely no negative effect
Samsung C9 Pro	For installation of the developed APK file and running of the VR-Foot-ReST application
Occulus Mobile HMD VR Gear	Mobile enabled Head Mounted Display.

5.2.2 Using Prototype

The APK file produced in the previous step was installed on an Android (Samsung Galaxy S) phone that has a 3.7 inch screen size for testing. The Android phone was inserted into the Android HMD compartment. During the system testing some notes were taken to improve and enhance the next version of the prototype like the font size, object adjustments, audio & video content adjustments, image size and so on.

5.2.3 Revising and Enhancing Prototype

Here 3 mobile application developers tested each version of the prototype using the framework as a guideline to compare and take notes on how to adjust, amend and/or enhance the current version so as to conform with the guidelines laid out by the framework and standard practice. This was then applied to the subsequent prototype

Table 5.2

Prototyping review comments and amendments for VR-Foot-ReST

Category	Opinions	Amendments
Time Frame	- 22 minutes therapy session is too long. - Can you make talk session shorter? This is very long and exhausting.	- The guided progressive relaxation and foot reflexology activities instructional session was cut in half from 22mins session to 12mins session consistent
Functionality	- Some of the navigation buttons aren't working properly. - Please check the left and up button in the take therapy session. - Voice command is very complex as several users differ in terms language, intonation, accent and so, not to mention background noise that may affect the clarity of voice command. Why don't you use other functionalities for navigation like head-tilt, remote control enabled navigation, or gyroscope.	- The coding for each navigation button was revisited repeatedly in unity 3D game engine C# mono developer app and corrected until the desired functionality is attained. - The navigations were changed from voice input command to remote control enabled navigation and head-tilt navigation command.
Compatibility Issues	- The APK file size is too large to play on the phone (54Gb). Can you convert/compress some of the audio/video files to smaller files like mp3?	- All the audio files with default .wav file type was converted to .mp3 files in audacity software and imported to Unity. The existing files were replaced by the new imported files the recompiled (build and run) for testing. - All the video files with default .3gp .wmv .mov .avi file type was converted to .mpeg4 files in adobe premier software for compatibility and to minimize the file sizes and imported to Unity. The existing files were replaced by the new imported files the recompiled (build and run) for testing. After which final APK file size reduced to 4Gb.
Content Error	- The navigation buttons are too large. They occupy too much space on the screen. Can you make the smaller? - The navigation buttons on the screen are centered and too big. Make it smaller and move to one corner. Preferably on the top or bottom left. - The video file in the take therapy session is slanted. Please reposition it and make it centered and full screen. - The water fall scenery looks a bit weird and unrealistic. Please do something to it to make it more realistic.	- The navigation buttons were made smaller and repositioned to the top left corner of the screen. - The video screen in the take therapy session was repositioned to full screen and aligned to mid view. - The waterfall scenery was enlarged by enlarge the 360 degree world view, which made the scenery more realistic and serene.

version iteratively until the desired prototype version is attained. The review feedbacks were categorized and presented in Table 5.2.

VR-Foot-ReST is an acronym for Virtual Reality Foot Reflexology Stress Therapy. The therapy exploits the multimodality of VR technology to enable users combat stress and for relaxation. For this system, the researcher combined both VR and RA. Using the design requirements laid out during the requirement gathering stage (Okere et al., 2016), the researcher focused on the visual/sight interaction components and aural/sound interaction components of the therapy and use RA (reflexology slipper) as the haptic component. The user then needs to put on the mobile HMD and RA while the user is lead by the system on a 10 to 12 minutes guided progressive relaxation and foot reflexology (GPR and FR) session. The GPR and FR session was built on the principle of the desired user haptic device or artifact. While, the user is immersed in VR environment, they would interact visually and aurally with VR-Foot-ReST while wearing the RA. Figure 5.5 presents the device components which include a mobile VR Head Mounted Display (HMD), a Bluetooth-game pad remote controller and reflexology slipper (RA). The information architecture as shown in Figure 5.6 presents the structural content of VR-Foot-ReST. The VR-Foot-ReST application screenshots and Unity3D game development environment is presented in Figure 5.1, 5.2, 5.3, 5.4 and Appendix F. Figure 5.7 and 5.8 presents the researcher demonstrating VR-Foot-ReST to the complementary therapy practitioner.

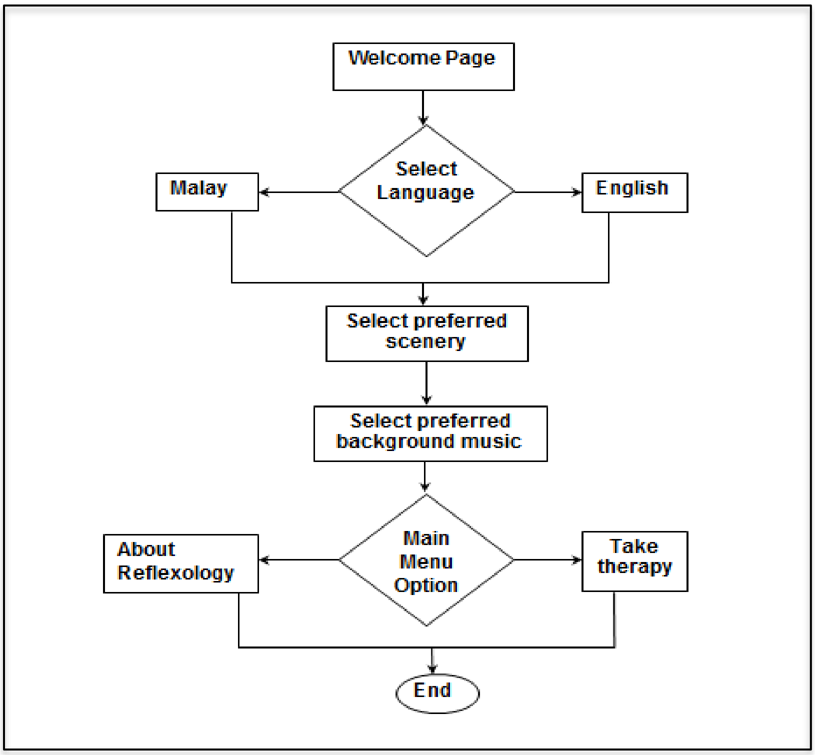


Figure 5.6. Information Architecture of VR-Foot-ReST

5.3 Prototype Demonstration

This phase presents the demonstration of the prototype with medical practitioners to prove that the idea works as discussed in section 3.3.3.3. The Table 5.3 presents the demographic profiles of the medical or complementary therapy practitioners, and subsequently discussed the main themes from the interview sessions.

Table 5.3

The medical or complementary therapy practitioners' demography

No	Gender	Occupation	Practising center	Practicing experience years
1	Male	Chinese complementary therapy & Acupunturist	Xing Ling Chinese Pysician & Acupuncturist Center, Kuching, Sarawak.	20years
2	Male	Professional Body Massuer, Reflexology&	Mat Urut Professional ffoot reflexology & body physiotherapist, Kuching, Sarawak.	17years

Figure 5.7. A physician Dr. X using the VR-FRST application during demonstration.

5.3.1 Effectiveness

The two practitioners both agreed that the VR-Foot-ReST prototype achieved its objective of relaxation and stress relief. The first practitioner (R1) expressed that the prototype does induce relaxation and stress relief, especially with the VR instructor guiding people towards relaxation. R1 also commented on the VR guided therapy session saying *"It feels a little bit like hypnosis, not in the sense of going to space or* *something imaginary; more like asking you to consciously clear your mind, breath in and out deeply, walk slowly and so on. And also with the colourful/serene environment, it is very good for relaxation*". The second practitioner (R2) also concurred, expressing that *"Yes the application is relaxing and reduces stress"*. Hence, both agreed that VR-Foot-ReST is effective for relaxation and stress relief.

Figure 5.8. Researcher demonstrates VR-Foot-ReST to a complementary therapist.

5.3.2 Safety

The researcher also inquired on the safety or risk concern that may be attributed to the VR-Foot-ReST prototype. R1 expressed that *"The slipper that provides the pressure to the reflex points was a bit too sharp, especially from the start but becomes bearable after a while. Perhaps you may want to regulate the pressure from the beginning and ease in slowly, to allow people to adjust to the pain".* R2 also added that "*The application is safe, but if your application is also meant for elderly or for the weak, then the HMD should be much lighter and not heavy; as light as wearing a pair of eyeglasses. And the pressure should be regulated so the pain can be bearable*". Hence, they both declared the prototype safe for usage, but added that future versions should make provisions for pressure exertion range intensity. So patients may increase or reduce amount of pressure they receive based on their personal preference. They also suggested that future versions of the prototype should also apply a different posture of sitting and receiving the therapy, asides the current standing and walking posture in the current prototype; giving the patients the chance to choose as well. However, the overall application is marvellous as expressed by R1, recommending the prototype to be introduced saying *"As you know, many patients in the world nowadays are experiencing a lot of stress due to the standard of living and so on. So applications like these are needed".*

5.3.3 Visual Components

The practitioners both agreed on the significant role the visual components of the application contributed to the therapeutic experience patients will perceive. R1 expressed that *"The jungle, the waterfall, the visual environment was quite relaxing* *and quite clear"*. R2 also expressed that *"The nature environment of the waterfall, the forest and so on is very good for the eyes and the mind. That is why people love to go to the forest to experience nature; it makes our mind cool down"*. R2 also noted the significant role of the visual aid in the form of animated gesture guide. Stating that without it, people may not be able to understand and properly perform the activities needed to achieve the desired result. This underlines the contribution of the visual component of the application on the relaxation and stress relief users will perceive.

5.3.4 Aural Component

The practitioners likewise both agreed on the significant role the aural (sound/voice) components of the application contributed to the therapeutic experience patients will perceive. With R1 expressing that "*the sound from the application was quite relaxing. It is not depressing as at all. Especially the natural stream and the waterfall, because I love swimming. So when I see and hear the stream and the waterfall, I really love it. The entire sound of the environment was very relaxing. The voice of the VR instructor was clear and audible enough. But you may want to increase the volume a little bit more"*; and R2 adding that "*The volume should be increased as I feel as though it was not loud enough. But the sound of nature in the application is quite relaxing. You know more people get sick in the urban areas than the rural areas. So the sounds are very relaxing*". This underlines the contribution of the aural component of the application on the relaxation and stress relief users will perceive.

5.3.5 Haptic & Interaction Components

On the haptic interaction front, reflexology slipper was the selected reflexology artifact (RA) meant to provide the pressure exertion on the reflex points of a person's foot. Okere et al. (2015) declared reflexology slippers to be amongst the sharpest pressure edges, hence amongst the most painful in the RA categories. This explained the reason why R1 expressed that "*from the starting the pain was a bit unbearable and quite irritating, perhaps because I am not used to such pressure and my body was adjusting to it. But after a while I felt better. It became okay"*. And R2 also expressing similar views that *"the slipper is quite painful, especially from the beginning (reflexology pebbles are not as painful as these slippers). And when the slipper is connected to an area of the body that is sick, the pain will be unbearable. Most of our attention will be on the slipper and the pain. So the pain should be bearable"*. Both practitioners pointed out the pain the haptic RA inflicts; and as is commonly known, reflexology induces pain on reflex points of the foot to improve health as was also concurred by R2 "*However, this pressure and pain benefits the body for blood circulation from our heart to the legs and other parts of the body to improve health (no pain, no gain yes?)"*. This highlights the contribution of the haptic component of the application on the therapy.

5.3.6 Overall Feedback

i. **Cost:** The practitioners also gave an overall overview of the prototype. R2 raised the concern of the potential cost of the prototype, expressing that *"for relaxation therapy, it is very good. I'm just worried that the finished product will be too expensive for low income earners. But for those who can afford it,* *it is very good for relaxation and stress relief. The pebbles found at the parks or recreational areas are free for people to use which is very good. But as you know, everything needs money. So I hope your application will be affordable".*

ii. **Time duration extension choice:** R1 then expressed that patients should be given the choice to choose the time duration of how long the therapy is preferred (15–30mins). This can then be achieved by increasing the activities in the guided progressive relaxation (GPR) instructional session.

iii. **Posture variety:** both practitioners noted that patients using the VR application be able to sit. Hence, recommending the design of two (2) posture designs; one sitting and the other standing/walking. R2 mentioned that *"especially for the elderly/weak or those with hypertension, standing/walking around may make them dizzy and fall. But the sitting posture will help them relax better".*

iv. **Language Variety:** R2 expressed that users should be given the choice to choose their preferred language. He added that *"in Malaysia, not everyone can understand English. So include Bahasa Melayu and other languages for people's convenience".*

v. **Light wearable devices:** the practitioners noted that the wearable devices should be as light as possible. R2 stated that "*the HMD should also be as light as possible especially for aged patients. They would not want to carry around the burden of the extra head weight".*

CHAPTER SIX
VR-FRST EVALUATION FOR RELAXATION AND STRESS RELIEF

6.1 Introduction

This chapter demonstrates the proof of concept of the framework which provides the demonstration and evaluation of VR-FRST on relaxation & stress relief using the Smith Relaxation States Inventory III (SRSI-3) (Smith, 2001). According to the ABC relaxation theory (Smith, 2001), which proposed that all approaches to relaxation have the potential to evoke one or more of the 12 relaxation states or (R-states) which were categorized into four (Barlow et al., 2007; Smith, 2007b, 2007a): Basic Relaxation; Core Mindfulness; Positive Energy; Transcendence. These approaches to relaxation and stress relief likewise have the potential to influence the users' stress states (Somatic Stress, Emotional Stress, and Cognitive Stress). This study examines the users' perceived stress and relaxation related states associated with VR-FootReST. It asks participants to indicate how they feel "now, at the present moment" on a 6-point Likert scale from 1 (not at all) to 6 (maximum).

6.2 Analysis & Results

The analysis of the studies was executed after data collection was completed. The choice of analytical tool to be used for analysis depends on the sort of analysis needed or required. As such, this study aims at comparing participants report scores during the pre and post experiments for the participants' relaxation states (R-states) as well as their stress-states. As such, IBM SPSS software (version 23.0.0; SPSS

Inc., Chicago, IL) was utilized to analyze and calculated the mean scores and standard deviation of the data collected during the pre-test and post-test for each variable against 1 (not at all / low R-state category) to 6 (maximum / hi R-state category), and presented in Table 6.2 & 6.3. The demographic distribution is presented in Table 6.1.

Table 6.1

Participants' demographic distribution

	Categories	***n = 30***
Gender	Male	18
	Female	12
Occupation	Student	30
Education level	Degree	8
	Master	10
	PhD	12
Marital Status	Single	17
	Married	12
	Divorced	1
Age	23-29	14
(min = 23	30-36	13
max = 43)	37-43	3

Table 6.2

Paired Samples Test

		Paired Differences					t	df	Sig. 2tailed
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Pre Transcendence Post Transcendence	-.94444	1.02117	.18644	-1.32575	-.56313	-5.066	29	.000
Pair 2	Pre Mindfulness Post Mindfulness	-1.50833	.88448	.16148	-1.83860	-1.17806	-9.340	29	.000
Pair 3	Pre Positive Energy Post Positive Energy	-1.59889	.80802	.14752	-1.90061	-1.29717	-10.838	29	.000
Pair 4	Pre Basic Relaxation Post Basic Relaxation	-1.80404	.87758	.16022	-2.13174	-1.47635	-11.259	29	.000
Pair 5	Pre Stress Post Stress	1.68571	1.00210	.18296	1.31152	2.05991	9.214	29	.000

Table 6.3

Mean and Standard Deviations for the experiment groups for Pre-test and Post-test categories

Categories	*n*	Mean	SD
Transcendence			
Pre-test	30	3.5	0. 76
Post-test	30	4.44	0.62
Mindfulness			
Pre-test	30	3.05	0.74
Post-test	30	4.56	0.43
Positive Energy			
Pre-test	30	3.4	0.64
Post-test	30	5.0	0.55
Basic Relaxation			
Pre-test	30	2.68	0.69
Post-test	30	4.48	0.44
Stress			
Pre-test	30	3.63	0.71
Post-test	30	1.95	0.49

Table 6.1 presents the demographic distribution of the participants that took part in the experiment. Figure 6.1 presents the users undergoing VR foot reflexology therapy with HMD, wireless JBL earphones, and reflexology slippers. Thirty participants (*n* = 30) from Universiti Utara Malaysia participated in the experimental group. 18 of the participants were male and the remaining 12 were female. 8 of the participants were degree student, 10 of the participants were Masters Students, and the remaining 12 were PhD students. 17 of the participants are single, 12 were married, with only one divorced participant. The participants have a mean age of 30.867 and a standard deviation of 4.71.

Figure 6.1: Users undergoing VR foot reflexology therapy with HMD, wireless JBL earphones, and reflexology slippers

From the results presented in Table 6.3, it can be noted that participants during the pre-test reported low levels of R-state category *"Basic Relaxation"* (M = 2.68, SD = 0.69). After taking the procedure, they reported increased levels of Basic Relaxation

(M = 4.48, SD = 0.44). Resulting in a 1.8 positive increase in mean scores, the most improved compared to other R-states categories. The independent sample T test also demonstrated that there is a statistical significant difference in the pre-test and post-test scores of Basic Relaxation ($t = -11.26$, $P < 0.05$). This implies that the VR - FRST effectively evokes R-state category of Basic relaxation.

Participants during the pre-test also reported average levels of R-state "Mindfulness" (M = 3.05, SD = 0.74). And after taking the procedure, they reported increased levels of R-state category mindfulness (M = 4.56, SD = 0.43). This resulted in a 1.51 positive increase in mean scores. The independent sample T test also demonstrated that there is a statistical significant difference in the pre-test and post-test scores of Mindfulness ($t = -9.34$, $P < 0.05$). This also implies that the VR - FRST effectively evokes R-state category of Mindfulness.

Participants during the pre-test also reported average levels of R-state *"Positive Energy"* (M = 3.4, SD = 0.64). And after taking the procedure, they reported increased levels of R-state category positive energy (M = 5.0, SD = 0.55). This also resulted in a 1.60 positive increase in mean scores. The independent sample T test also demonstrated that there is a statistical significant difference in the pre-test and post-test scores of Positive Energy ($t = -10.84$, $P < 0.05$). This also implies that the VR - FRST effectively evokes R-state category of Positive Energy.

Participants during the pre-test also reported average levels of R-state *"Transcendence"* (M = 3.5, SD = 0.76). And after taking the procedure, they reported increased levels of R-state category transcendence (M = 4.44, SD = 0.62).

This also resulted in a 0.94 positive increase in mean scores. The independent sample T test also demonstrated that there is a statistical significant difference in the pre-test and post-test scores of Transcendence ($t = -5.066$, $P < 0.05$). This also implies that the VR - FRST effectively evokes R-state category of Transcendence despite not as much as the previous three R-state categories, but still a positive influence.

Participants were also examined for stress levels during the study. During the pre-test session, participants reported averagely high levels of stress ($M = 3.63$, $SD = 0.76$). After taking the procedure, the participants reported significantly decreased levels of stress ($M = 1.95$, $SD = 0.49$). This resulted in a 1.67 decrease in mean scores. The independent sample T-test also demonstrated that there is a statistical significant difference in the pre-test and post-test score of stress level ($t = 9.214$, $P < 0.05$). This implies that the VR-FRST has a very strong impact on users' stress relief.

Consequently, it was initially hypothesized that, participants that undergo the VR foot reflexology stress therapy will report an increased "R-states" in at least one of the four (4) relaxation state categories; and reduced "stress-state". However, participants reported increased R-state in all four (4) relaxation state categories. R-state category basic relaxation revealed the highest or most influenced R-state category increasing from a mean score of 2.68 to 4.49. This is followed by R-state category Positive Energy, which saw an increased mean score from 3.4 to 5.0. This is then followed by R-state category Mindfulness, which saw an increased mean score from 3.05 to 4.44. This is also then finally followed by R-state category Transcendence, which saw an increased mean score from 3.5 to 4.44. Therefore, users that undergo the VR foot reflexology stress therapy will report an increased or improved R-state in all four (4) relaxation state categories. As shown in Table 6.4.

In addition to that, participants did not only experience increased relaxation states after undergoing the procedure, they also experience reduced stress state. The reported stress state by the participants before undergoing the procedure was at an averagely high pre-test mean score of 3.63 and standard deviation of 0.71, which reduced after undergoing the procedure with a mean post-test score of 1.95 and standard deviation of 0.49. Hence, as shown in Table 6.4, users that undergo the VR foot reflexology stress therapy will report a decreased or reduction in their stress-state.

Table 6.4

Summary of statistical significance of each variable

	Variable	**Statistical significance**
1	Transcendence	Significant increase
2	Mindfulness	Significant increase
3	Positive Energy	Significant increase
4	Basic Relaxation	Significant increase
5	Stress	Significant decrease

From a theoretical perspective, the study findings support both the ABC and the Neuman relaxation model. The ABC relaxation theory highlighted that different approaches to relaxation have different positive psychological effects and invokes one or several of the 12 R-states, categorized into four: (Basic Relaxation; Core Mindfulness; Positive Energy Transcendence) and likewise have the potential to influence the users' stress states (Somatic Stress, Emotional Stress, and Cognitive

Stress) (Barlow et al., 2007; Smith, 2007b, 2007a). Hence, the study finding revealed the VR-FRST approach to relaxation and stress relief evoked all 4 users' R-state categories as well as the users' stress states.

It also supports the Neuman System Model from the context of this research as outlined in section 2.6.1 highlighted that users' environment which could either be internal, external, or created are usually the source of their stress; and without proper management of these stressors may disrupt the person's equilibrium, contributing to poor health, delayed recovery, depression, anxiety and so on. And the right intervention technique employed (VR-FRST) will assists users to achieve relaxation state and/or stress relief (Neuman & Fawcett, 2002; Shah et al., 2015).

These findings therefore supports the claims of previous studies on the use of VR combined with health knowledge in health domain is a valuable tool to promote postive stimuli, well-being relaxation and stress relief (Baños et al., 2011; Jerdan et al., 2018; Pallavicini et al., 2016; Shah et al., 2015). In the study of Shah et al., (2015) on VR mood induction procedure for a VR-based stress management program, revealed a significant reduction in users' depression and stress levels. The study of Cikajlo, Staba, Vrhovac, Larkin, and Roddy (2017) also revealed the potential of VR-based mindfulness applications to possess a positive impact on stress.

CHAPTER SEVEN
CONCLUSION

7.1 Introduction

The preceding chapters presented the research endeavours which include the examination of relevant literature, methodology applied, data collection and analysis, the framework development and evaluation using expert review, prototype development and evaluation for relaxation and stress relief, and finally the findings of the effectiveness of VR-FRST on relaxation and stress relief. The current chapter summarizes the overall research works which include addressing the research objectives as stated in Chapter 1, notable findings, research limitations, contributions and present recommendations for future works.

7.2 Virtual Reality Foot Reflexology Stress Therapy

The public-driven investment on reflexology's product quality and safety have become one of healthcare's top research priorities (Robinson et al., 2011). This public driven interest has made the reputation of foot reflexology to continually increase despite being around for several centuries. The advantage, uses and significance of the therapy have motivated several attempts to simulate as can be seen in some electronic foot massage devices, or even locally as can be seen from some reflexology artifacts, however, none using VR. But before attempting to simulate the therapy in a virtual environment, a multimodal interaction framework components for VR foot reflexology stress therapy has to be identified; the components combined to develop the framework; and then the validated through expert validation and prototyping proof-of-concept.

7.3 Addressing the Research Objectives

Prior to conducting this research, the three main objectives were identified to forge a direct path to lead the research and proposing a validated multimodal interaction framework for VR foot reflexology stress therapy. Each endeavour carried out to address each of the research objectives are summarized below:

i. To determine the components of the integrated multimodal interaction framework for Virtual Reality Foot Reflexology Stress Therapy.
ii. To develop the integrated multimodal interaction framework for Virtual Reality Foot Reflexology Stress Therapy using the identified components.
iii. To evaluate the effectiveness of the integrated multimodal interaction framework for Virtual Reality Foot Reflexology Stress Therapy on relaxation and stress relief.

1. To determine the components of the integrated multimodal interaction framework for Virtual Reality Foot Reflexology Stress Therapy (VR-FRST) Framework

In addressing the first research question, a systematic literature review was carried out to reveal the multimodal interaction components by using "VR stress therapy", "VR framework", "multimodal interaction framework", and "mobile VR" as keywords. During the systematic literature review, three criteria were used to as criteria for selecting article/resource, which are: (i) the study was published no later than 2005; (ii) published in a reputable journal of HCI and/or VR; (iii) revealed/discussed components or elements for the interaction framework. However, notable articles beyond 2005 which also contributes to identifying the relevant components of the interaction framework was also reviewed and selected for inclusion.

Consequent to the SLR, a number of possible framework component was discovered and 5 of them in categories were selected for inclusion in the framework as majority of other elements fell within these selected categories. These include: technology, segment composition, content composition, design principles, and user/entities. This was presented in chapter 4. Hence, the 1nd objective is achieved.

2. *To develop a multimodal interaction framework for VR-FRST application using the identified components.*

In addressing this research objective, literature and industry revealed the composition of the identified framework components. Findings from comparative studies on existing models and applications seconded with the identified composition of each element. These were also seconded by existing theories and principles in related domains, such as theories and principles of multimodality, information architecture, user interface principles and layout, and ABC relaxation theory.

These components were subsequently combined to form a multimodal interaction framework for VR-FRST application, relating to each other. The content composition component outlined the multimodal interaction architecture, which outlines how components are allocated to hardware devices and the communication system allowing intercommunication between these hardware devices from users' input all the way to the system output. The system segment composition comprises of the application's opening, content, and closing segments. The design principle comprising of the multimedia element design principle, information architecture principles and theories, user interface and layout principles, and traditional foot reflexology user requirements. This then followed by the Entities and Technology component which may either be electronic or none electronic as is in line with (Angkananon et al., 2013b, 2013c). Each component relating to the other forms the multimodal interaction framework for VR-FRST.

Having constructed the multimodal interaction VR-FRST framework, the next stop is to validate the multimodal interaction framework for VR foot reflexology stress therapy. For this purpose, Expert review is employed, with these experts coming from the field of HCI or related domain. These experts used their experience and expertise from their respective domain to review and give feedback on the multimodal interaction framework for VR foot reflexology therapy. The reviews took into consideration certain guidelines to guide these experts on the review process. These guidelines includes the end users' familiarity with the terminologies used, deviation from standard practices, relevancy of the components, information architecture, interactivity, errors or mistaken assumptions, readability, clarity and easiness to understand. This will enable a simple and straightforward translation during development. These review feedback were compiled and used to address the challenges and issues raised by the experts on the framework. This is outlined in chapter 4, and consequently achieving the second research objective.

3. *To evaluate the effectiveness of the multimodal interaction framework for VR-FRST on relaxation and stress relief*

After the completion and validation of the multimodal interaction framework for VR-FRST, this is followed by the prototype development as the proof-of-concept for the proposed framework. A quasi-experimental study was carried out using thirty participants (n=30) who report feeling stressed. The Smith Relaxation States inventory III (SRSI-3) was utilized as instrument for data collection from these respondents during a pre and post intervention session. Study findings revealed that VR-FRST effectively evokes the relaxation state and stress state categories of transcendence, mindfulness, positive energy, and basic relaxation; as the independent sample T-test demonstrated a statistical significant difference in the pre-test and post-test results for the aforementioned relaxation and stress states. This was presented in chapter 5, hence, achieving the final objective.

7.4 Limitations

The research sample participants were only drawn from the Universiti Utara Malaysia (UUM) populace, and are associated with tension, stress, or are experiencing the symptoms higher levels of stress. These participants were limited to only participants capable of expressing his/her opinions using the English language. That is to say, the participants had to possess a moderate English speaking fluency.

7.5 Contribution

The following are the theoretical, practical and commercial contributions of this research.

- From a theoretical perspective, the study finding revealed the VR-FRST approach to relaxation and stress relief evoked all 4 users' R-state categories as well as the users' stress states. This supports both the ABC and the Neuman relaxation model. The ABC relaxation theory highlighted that different approaches to relaxation have different positive psychological effects and invokes one or several of the 4 R-states, categories. It also supports the Neuman System Model, which expressed that the right VR intervention technique employed (VR-FRST) will assist users to achieve relaxation state and/or stress relief (Neuman & Fawcett, 2002; Shah et al., 2015).

- The study contributes to the field of interaction design by proposing an integrated multimodal interaction framework for virtual reality stress therapy application. This will serve as foundation for developers developing a VR technology for foot reflexology or related domain. The evaluation of the prototype and the outcome of this evaluation also serves as proof-of-concept for the contribution and implication of VR multimodality in reflexology therapy.

- A practical contribution of the prototype will be offering the VR-FRST as an alternative substitute for the traditional foot reflexology therapy in relaxation, stress relief and complementary therapy.

- Following the completion and implementation of the prototype, and successive upgrades, product commercialization and distribution may then commence.

7.6 Future Works

In this research, mobile VR technology was utilized during prototyping, combined with reflexology artifacts in the application of the multimodal interaction in VR foot reflexology stress therapy application. Future works and future developments should utilize the console VR technology, simulating the multimodal interactivity based on the guidelines from the framework for VR foot reflexology therapy.

Future research may also execute a comparative research to compare and contrast the alternative applications of reflexology stress therapy (VR-FRST, TFR therapy, and reflexology using RA). Future works should also provide empirical justifications using other relevant measures like EEG, to examine how effective VR-FRST is on stress relief and relaxation, as well as the effect of VR-FRST on other health conditions that TFR has shown to be effective for.

Future research should also explore the usability, user experience and user hedonic experience to incorporate into the design principles to enhance users' ease of learning, ease of use, minimal errors, easy to remember, and satisfaction in the VR foot reflexology stress therapy. This will improve how efficient, effective, safe, learnable and memorable the ultimate product will be (Preece, Rogers, & Sharp, 2015). Other user VR experience factors should also be explored by future research such as immersion, presence, suspension of disbelief, involvement and engagement, and peripheral awareness on VR-FRST, as studies have shown that these user experiences are essential mediator which allows the activation of realistic emotions by any VE (Parsons & Rizzo, 2008; Diemer et al., 2015; Peperkorn et al., 2015).

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Appendix A
Prototype Demonstration with Medical Experts

Dear Sir/Madam,

I am Prince-Hector C. Okere (900725), currently pursuing a PhD program in Multimedia at University Utara Malaysia (UUM), under the Supervision of Dr. Juliana Aida Abu Bakar and Dr. Ruzinoor Che Mat. I am interested in your expertise which is either in Complementary Therapy, Massage Therapy, Stress Therapy, Nursing Care, Foot Reflexology and/or related areas. And have been practicing in said area for at least five (5) years.

With the expertise you possess, I would be honoured to have you review the prototype **VIRTUAL REALITY FOOT REFLEXOLOGY STRESS THERAPY (VR-Foot-ReST).** The application is aimed at offering a complimentary application for foot reflexology using VR and as an alternative for Traditional foot reflexology in relaxation, stress relief and complementary therapy.

Every sensitive information supplied will be treated as confidential and will be used for research purposes, which will be reported anonymously in academic publications.
Please feel free to contact me by email (okerejunior@yahoo.com) in regards to any queries or my supervisor suziah@petronas.com.my
Thanking you for your time and assistance.

EXPERT/REVIEWER DETAILS

Name: ______________________________

Age: ______________________ Gender: __________

Highest Education Level ______________________________

Occupation: ______________________________

Working Experience (years): ______________________________

I consented to participate in this research.

Signature: ______________________________

1.	**What do you think of the application?**
R1	It is quite relaxing. Like we can simply go into the forest scenery and relax relax relax relax.
R2	For relaxation therapy, it is very good. I'm just worried that the finished product will be too expensive for low income earners. But for those who can afford it, it is very good for relaxation and stress relief. The pebbles found at the parks or recreational areas are free for people to use which is very good. But as you know, everything needs money. So I hope your application will be affordable.

2.	**What recommendations will you give to better improve the prototype?**
R1	• The GPR instructional activity session may be improved upon. Maybe include lower limbs relaxation activities. • The time duration maybe increased (give patients the choice to choose). • Let the patients using the VR application be able to sit. Perhaps design Two (2) types one sitting and the other standing and compare or see what users prefer (give patients the choice to choose)
R2	• The HMD should also be as light as possible especially for aged patients. They would not want to carry around the burden of the extra head weight. • Also the posture, you should consider also designing one for sitting. Especially for the elderly or those with hypertension, it may make them dizzy and fall. But the sitting posture will help them relax better. • Give users the choice to choose preferred language. As in Malaysia, not everyone can understand English. So include Bahasa Melayu and other languages for people's convenience.

3.	**Are you familiar with some of the reflexology artifacts like slipper, pebbles, mats, or electronic reflexology massage devices?**
R1	Yes
R2	Yes

4.	**How will you compare having the Traditional therapy to Reflexology Artifacts?**
R1	Actually, they are almost the same. The differences may just include the person applying the therapy, how much energy they use, and so on.
R2	They are quite similar

5.	**In your opinion, does the visual component of the application contribute to the relaxation and stress relief users will perceive? (The nature background, Animated, instructions, and so on)**
R1	The jungle, the waterfall, the visual environment was quite relaxing and quite clear.
R2	The nature environment of the waterfall, the forest and so on is very good for the eyes and the mind. That is why people love to go to the forest to experience nature, it makes our mind cool down.

6.	**In your opinion, does the Sound component of the application contribute to the relaxation and stress relief users will perceive? (background nature sounds, instructional voice component, background music and so on) ?**
R1	It was quite relaxing. It is not depressing as at all. Especially the natural stream and the waterfall, because I love swimming. So when I see the stream and the waterfall, I really love it. The entire sound of the environment was very relaxing. The voice of

	the VR instructor was clear and audible enough. But you may want to increase the volume a little bit more.
R2	The volume should be increased as I feel as though it was not loud enough. But the sound of nature in the application is quite relaxing. You know more people get sick in the urban areas than the rural areas. So the sounds are very relaxing.

7.	**In your opinion, does the haptic component of the application contribute to the relaxation and stress relief users will perceive? (Reflexology slipper and room temperature)?**
R1	From the starting the pain was a bit unbearable and quite irritating, perhaps because I am not used to such pressure and my body was adjusting to it. But after a while I felt better. It became okay
R2	The slipper is quite painful especially from the beginning (reflexology pebbles are not as painful as these slippers). And when the slipper is connected to an area of the body that is sick, the pain will be unbearable. Most of our attention will be on the slipper and the pain. So the pain should be bearable. Because this pressure and pain benefits the body for blood circulation from our heart to the legs and other parts of the body to improve health (no pain, no gain yes).

8.	**Are there any risk or safety concerns you will attribute to the usage of this application?**
R1	The slipper that provides the pressure to the reflex points was a bit too sharp especially from the start but becomes bearable after a while. Perhaps you may want to regulate the pressure from the beginning and ease in slowly. To allow people to adjust to the pain.
R2	The application is safe. But if your application is also meant for elderly or for the weak, then the HMD should be much lighter and not heavy. As light as wearing a pair of eyeglasses. And the pressure should be regulated so the pain can be bearable.

9.	**How will you compare having the therapy using RA to VR-Foot-ReST**
R1	You know most people are very busy and don't have time to go to the outdoors and relax. But with your VR application, it allows people to explore clear, realistic and relaxing outdoors to relax. And with the VR instructor, instructing Users on how to walk, stretch, breath in and out deeply, with the soft sounds which calm their minds and so on, allows the people to fully relax.
R2	The pebbles found at the parks or recreational areas are free for people to use which is very good. But as you know, everything needs money. So I hope your application will be affordable.

10.	**Are there any distracting, unnecessary or irrelevant component of the application that should be avoided that may alter the users' relaxation and stress relief?**
R1	I don't think so. It was very clear and relaxing.
R2	You may want to do without the visual aid which shows people how to perform the activities and just use voice instructions. As the visual aid may obstruct the natural view people see. But also people may not be able to understand and properly perform the activities needed, hence the visual aid. So people should be able to choose.

11.	**In your opinion, does the product achieve its objective for relaxation and stress relief?**

R1	Yes it does. Especially with the VR instructor guiding people towards relaxation. Feels a little bit like hypnosis. Not in the sense of going to space or something imaginary; more like asking you to consciously clear your mind, breath in and out deeply, walk slowly and so on. And also with the colourful/serene environment, it is very good for relaxation.
R2	Yes the application is relaxing and reduces stress.

	12. Have you seen or used any similar application?
R1	Not at all. This was my 1st time.
R2	No. It is my first time.

	13. How does the application measure up to your expectations before and after usage?
R1	It is quite marvellous. You know from the onset, I had no idea what the prototype was all about, but after usage, wow! It is quite marvellous.
R2	At first glance, it looked very expensive. And as people are not aware of this form of therapy, the price may scare them away. Yes, it is said to be for reflexology therapy stress therapy. So yes I experienced all of that. But due to the pain, the relaxation process comes in after using it for some time.

	14. How likely are you to recommend the finished product to a friend or patient needing relaxation and stress relief?
R1	It can be introduced. As you know, many patients in the world nowadays are experiencing a lot of stress due to standard of living and so on. So applications like these are needed.
R2	

Appendix B

Smith Relaxation States Inventory 3 Instrument

R-STATES	**(A) Transcendence**		
	Timeless/Boundless	**A1**	Things seem TIMELESS, BOUNDLESS, or INFINITE?
	Mystery	**A2**	I sense the DEEP MYSTERY of things beyond my understanding?
	Prayerful	**A3**	I feel PRAYERFUL or REVERENT?
	Awe and Wonder	**A4**	Things seem AMAZING, AWESOME, and EXTRAORDINARY?
	(B) Mindfulness		
	Quiet	**B1.**	My mind is SILENT and calm (I am not thinking about anything)?
		B2.	My mind is QUIET and STILL?
	Aware / Focused	**B3.**	I feel AWARE, FOCUSED, and CLEAR?
	Accepting	**B4.**	Right now I recognize the wisdom of sometimes ACCEPTING things as they are?
		B5.	Presently I feel there's no need to try to change things that simply can't be changed?
	Innocent	**B6.**	I feel INNOCENT and CHILDLIKE?
	Centering	**B7.**	I feel like I am living fully and SIMPLY in the PRESENT, not distracted by past or future concerns?
		B8.	I feel fully focused and ABSORBED in what I am doing?
	Awakening	**B9.**	Things seem FRESH and NEW, as if I am seeing them for the first time?
	(C) Positive Energy		
	Joyful (Happy)	**C1.**	I am HAPPY?
		C2.	I feel JOYFUL?
	Optimistic	**C3**	I feel trusting; I feel I can rely on someone or something?
	Energized	**C4**	I feel ENERGIZED, CONFIDENT, and STRENGTHENED?
	Thankful / Loving	**C5.**	I feel THANKFUL?
		C6.	I feel LOVING?
	(D) Basic Relaxation		
	Mentally Relaxed (At ease)	**D1.**	I feel AT PEACE?
		D2.	I feel AT EASE?
		D3.	I feel CAREFREE?
	Physically Relaxed	**D4.**	My muscles are SO RELAXED that they feel LIMP?
		D5.	My hands, arms, or legs are SO RELAXED that they feel WARM and HEAVY?
		D6.	My body is PHYSICALLY RELAXED
	Disengaged	**D7.**	I feel DISTANT and FAR AWAY from my cares and concerns?
		D8.	I feel INDIFFERENT and DETACHED from my cares and concerns?
	Sleepy	**D9.**	I feel DROWSY and SLEEPY?
		D10.	I am DOZING OFF or NAPPING?
	Rested/Refreshed	**D11.**	I feel RESTED and REFRESHED
	(E) Stress		
Stress-States	*Somatic Stress*	**E1.**	My muscles feel TIGHT and TENSE (clenched fist or jaws; furrowed brow)?
		E2.	My BREATHING is NERVOUS and UNEVEN (Or shallow and hurried)?
		E3.	I feel PHYSICAL DISCOMFORT or PAIN (backaches, headaches, fatigue)?
	Emotional Stress	**E4.**	I feel IRRITATED or ANGRY?
		E5.	I feel SAD, DEPRESSED, or BLUE?
		E6.	I feel ANXIOUS?
	Cognitive Stress	**E7.**	I am WORRYING?
		E8.	TROUBLESOME THOUGHTS are going through my mind?

Appendix C

Experts Review Feedbacks, Analysis & Modifications

Review Section	Review rating	Review critiques or/and recommendation	Analysis & review modification
Technology	3 of the experts expressed that the technology element is relevant. 1 expressed that some may not be relevant and the remaining 3 expressed that some are definitely not relevant, and presented their review feedbacks, critiques and recommendations to address their concerns	- The haptic foot massaging device, is it also under the integrated or console platform? if no, please make provision for it in the technology section. - Desktop as in Windows? How about Mac's environment? What does console refer to? Gaming console or...? - Can consider including "Standalone" technology. - Options for technology are divided into Integrated or mobile? But there's also integrated platform for mobile. - Desktop is the targeted platform? Define console - The haptic foot massaging device, is it also under the integrated or console platform? if no, please make provision for it in the technology section.	The experts demonstrated the unclear presentation of the technology element. Hence the technology element was re-categorized and restructured following the recommendations of (Angkananon et al., 2013b, 2013c; Burden, 2016).Hence, addressing all the concerns raised by the expert reviewers.
Content composition	Majority of the experts expressed that the content composition element is easy to understand, and presented 1 review feedbacks, critiques, concerns or recommendations to address.	- A bit difficult to differentiate as recognizers and synthesizers are inline - Fussion or Fusion	- The experts demonstrated the unclear difference of the multimodal recognizers and synthesizers in the framework. This was addressed by distinguishing the synthesizers and recognizers through grouping each category in a doted white rounded square. - Experts also recommended that the appropriate spelling for the terminology “Fusion” be verified. This was addressed consistent to Dumas et al.'s (2009) multimodal interaction

			architecture.
Segment composition	6 of the experts expressed that the segment composition element is relevant. none expressed that some may not be relevant and only 1 expressed that some are definitely not relevant, and presented their review feedbacks, critiques and recommendations to address their concerns	- What about "Gamified Elements" in Presentation styles, which is largely the beauty of incorporating VR.	Smith et al. (2000) expressed that all forms of relaxation involve sustaining passive simple focus; the opposite of discursive effort. In everyday life, we strive, and our attention moves discursively and digressing from complex topic to topic; However in relaxation, we let go, and we focus on just one simple thing (relaxation stimuli). Gamification entails increasing brain activity which may include cognitive process, working memory and so on (Howard-Jones, Jay, Mason, & Jones, 2016).This contradicts the overall target of the therapy which aims at sustaining attention while diminishing overt behaviour and covert or cognitive activity (Smith et al., 2000). Hence, Gamification is excluded from the framework.
Design Principles	3 of the experts expressed that the design principles element is relevant. 1 expressed that some may not be relevant and the remaining 3 expressed that some are definitely not relevant, and presented their review feedbacks, critiques and recommendations to address their concerns	- Is graphics a multimedia element? Do you mean image? Please confirm. - All are relevant, but they should be captured under one (or more) known design principle -to which the elements (like text, graphics, etc) can lay claim to. For example, is Shneiderman's user interface design principle applicable, or is it Cooper's interaction framework for the multimedia element design. - The MMEDP's details could be more specific.	The design principles outlined in the framework was motivated by several prominent researchers like Norman, Nielson and Molich, Shneidermanand Plaisant amongst others with justifications. However, Alan Cooper deals with the interaction design between people technology and business and the development approaches and development team. This is not the focus of the framework; hence Alan Cooper’s “About face interaction design” was excluded.
Multimedia Elements Design Principles	6 of the experts expressed that the multimedia element design principles is easy to understand. None expressed that the MMEDP needs some explanation, except for 1 who expressed that the MMEDP needs very detail explanation, and presenting their review feedbacks, critiques and recommendations to address their concerns.	- Suggestion: include Interaction element since it's a core binding element for interactive multimedia product. - Is graphics a multimedia element? Do you mean image? Please confirm.	Interactivity was included in the design principle as a binding component of multimedia products. Graphic is an established multimedia element. Though sometimes referred to as graphical images (Rawi et al., 2015).

i.	Texts	5 of the experts expressed that the text multimedia element is easy to understand. None expressed that the text needs some explanation, except for 2 who expressed that the text multimedia element needs very detail explanation, and presented their review feedbacks, critiques and recommendations to address their concerns.	- Suggested to add maximum number of prominent colour usage in one design. - Easy terms like what?; consistent colour without any reckon to colour type and class?; and how is important content is expected to be highlighted: with colour or text font size or alignment.	
ii.	Graphic	5 of the experts expressed that the graphic multimedia element is easy to understand. None expressed that the graphic needs some explanation, except for 2 who expressed that the graphic multimedia element needs very detail explanation, and presented their review feedbacks, critiques and recommendations to address their concerns.	- What do you mean by consistency in graphic? Probably you can mention the two major categories: bitmap vs. vector - Good quality in range of what and what pixels, or frame size;	
iii.	Animation	4 of the experts expressed that the animation multimedia element is easy to understand. 1expressed that the animation needs some explanation, except for 2 who expressed that the animation multimedia element needs very detail explanation, and presented their review feedbacks, critiques and recommendations to address their concerns.	- What is an appropriate movement for an animation? Could be clarified. - What is the appropriate movement, per second, etc.	Experts requested the clarification of "appropriate movement of animation". The principle was paraphrased for clarity purpose to "Animation actions must match audio output corresponding to user goals"
iv.	Audio	6 of the experts expressed that the audio multimedia element is easy to understand. None expressed that the audio needs some explanation, except for 1 who expressed that the audio multimedia element needs very detail explanation, and presented their review feedbacks, critiques and recommendations to address their concerns.	- Small size of what size range	Experts raised the concern of "use small size of what size range". The principle "use small sized audio file" was removed as focus is allocated to the file codec and compatibility (MP3). MP3 files are generally compatible and have small file sizes.
v.	Video	5 of the experts expressed that the video	- Size of video? Format of video which is	In addressing this concern raised by the experts. The

	multimedia element is easy to understand. 1expressed that the video needs some explanation, except for 1 who expressed that the video multimedia element needs very detail explanation, and presented their review feedbacks, critiques and recommendations to address their concerns.	appropriate for the said purpose?	principle "Use common video codec (MP4)" was added to the design principles for video. The Mp4 video format is an ISO Base Media File Format (Amon, Rathgen, & Singer, 2007)
Information Architecture Principles and Theories	Majority of the experts expressed that the Information Architecture Principles and Theories element is easy to understand, and presented no review feedbacks, critiques, concerns or recommendations to address.	---	
User Interface & Layout	5 of the experts expressed that the user interface & layout element is easy to understand. 1expressed that the user interface & layout needs some explanation, except for 1 who expressed that the user interface & layout element needs very detail explanation, and presented their review feedbacks, critiques and recommendations to address their concerns.	- Why is the 1st guideline a replica of TFR user requirements' 1st guideline? I think it should be excluded from this segment	This principle "provide multiple relaxing scenery" was excluded from the User interface and Layout segment as it is a replica of the 1st principle in the TFR User requirement segment.
TFR User Requirements	5 of the experts expressed that the TFR user requirements element is easy to understand. 1expressed that the user interface & layout needs some explanation, except for 1 who expressed that the user interface & layout element needs very detail explanation, and presented their review feedbacks, critiques and recommendations to address their concerns.	- What is TFR? please write in full or include in Legend	TFR is an acronym for the terminology Traditional Foot Reflexology. The acronym was removed from the framework and replaced by the full terminology "Traditional Foot Reflexology"
Overall Framework	Majority of the experts expressed that the overall framework is easy to understand, and presented no review feedbacks, critiques, concerns or recommendations to address.	- The connections are OK, but the sentences don't show clear relation to any component - I want to see the relation for the definitions in sentences describing the	- Relation definition was outlined in the legend, highlighting each relation and its interpretation or meaning. - Detailed description of each framework composition and

		terms use relation to any component - For a framework, it is readable but the details of the MME Design Principles could be more specific. - Basic Framework Hierarchy is good, but provides the relation or where Definition of Terms is used, so that is easier to understand - It is good if the researcher can provide more details for the introduction. For example, is the app is a web-based type of app? Is the framework will be generalized or more specified to certain platform/device? If it will be generalized, the UI & layout segment should provide more info on the approach that will be used for managing multiple layout settings. How is this VR-FRST works? As a tutorial app or presentation layer installed to a foot reflexology machine? BTW, what is TFR ? - The arrow lines in the framework have different thickness levels and this is not captured in the legend. - Dotted arrows that connect the multimedia elements with the design principles are not captured in the legend.	justification is outlined in the Thesis Table 4.5. - As is outlined within the framework, the domain is VR, and the technology may include, mobile, integrated or standalone.

Appendix D

Systematic Literature Review

Author & Year	Subject matter	Framework components	Remarks
(Larson et al., 2003)	W3C Multimodal Interaction Framework	- Human user - Input - Output - Interaction manager - Interaction Architecture - session component - System and Environment component	Introduces the W3C Multimodal Interaction Framework, and identifies the major components for multimodal systems. Each component represents a set of related functions.
(Beaudouin-lafon, 2004)	Improving user interfaces through designing interaction	- Users - Environments - Artifacts - Computer system - Action/command - Feedback/response	The researcher claimed that the only way to significantly improve user interfaces is to shift the research focus from designing interfaces to designing interaction. This requires powerful interaction models, a better understanding of both the sensory-motor details of interaction and a broader view of interaction in the context of use. It also requires novel interaction architectures that address reinterpretability, resilience and scalability.
(Foulger, 2004)	Models of the Communication Process	- Information source - Transmitter - Receiver - Message - Destination - Feedback	This paper presents the classic communication models that are taught in introducing students to interpersonal communication and mass communication, including Shannon's information theory model (the active model), a cybernetic model that includes feedback (the interactive model, an intermediary model (sometimes referred to as a gatekeeper model of the two-step flow), and the transactive model
(Karam, 2006)	A Framework For Researching and Designing Gesture-	- User - Application Domain (User-task, interaction context, user goals),	Framework to support a systematic approach for designing freehand gesture-based interactions. The authors designed and evaluated (analytically and empirically) gestural interaction techniques for two broad

	based human computer Interactions	- Enabling technology (Input device, System performance) - Response system/ output (resulting artifact, feedback), - Gesture (gesture style, and gesture set)	categories of freehand gestures we specified – spatial gestures, and surface gestures. In the design activity, they discovered and proposed the core design principles and guidelines, and validated them via user studies.
(Klink, 2006)	The use of interaction methods in a blended	- direct communication in the same time and at the same place - people-technology interaction - technology to mediate people-people interaction	The use of interaction methods in a blended learning environment: evaluating methods in blended learning environment in two courses of a Masters program at the university of south Australia, unit systems engineering & evaluation centre.
(O'Brien et al., 2008)	Developing a framework for intuitive human-computer interaction.	- Seeking user goals / task as User behaviours are oriented toward achieving goals - Performing well-learned behaviour - Determining what to do next / transition - Metacognition is the cognitive mechanism through which humans evaluate and monitor their own thinking processes and knowledge content	Based on synthesis of the reviews, the author reorganized key themes into an organizational framework for intuitive HCI and developed a working definition and framework that allow the human to use a combination of prior experience and feedforward methods to achieve an individual's functional and abstract goals.
(Chorianopoulos, 2008)	User Interface Design Principles for Interactive Television Applications	- Design Principles (interactivity, navigation, content delivery, group viewing, multiple level of attention, TV grammar and aesthetics, infotainment) - Entities (User & system) - Technology	In this research, the UI principles were explicitly addressed in an ITV prototype that has been tested with users. The proposed set of ITV UI principles was presented as a list of high-level and generic design factors, which describe the design space of feasible ITV applications. Overall, the proposed principles facilitate the design process of early interactive prototypes. In
(Rukzio et al., 2008)	The Physical Mobile Interaction Framework (PMIF)	- Requirement - Interaction architecture / interaction component - Direct manipulation (touching, pointing, scanning) - Smart object - Technology (mobile device) - Segment composition - Interaction entities (user, mobile tourist guide,	The author presented a physical mobile interaction framework for using mobile devices as mediator for the interaction with a physical object and discussed purpose, need, training, information overload, item headings, initial items, and activity. Klink

		server, smart object)	
(Vyas et al., 2008)	Role of artifacts in mediated communication.	- Entities (user, organisation, culture/society) - Segment - interaction	Based on our ethnographic fieldwork on understanding cooperative design practices of industrial design students and researchers, the researchers described several experiential practices that are supported by design-related artefacts such as sketches, drawings, physical models and explorative prototypes – used and developed in designers' everyday work. This is aimed at developing technologies to support designers' everyday practices.
(Dumas et al., 2009)	Multimodal system architecture	- Input modalities - Modality recognizers and processors - Output modalities - Modality synthesizers - Integration committee (Input modality fusion - Context user model history - Output modality fission - Dialog management) - application	The author presents the features and advantages associated with multimodal interaction, with a focus on particular findings and guidelines, as well as cognitive foundations underlying multimodal interaction. Consequently, focus was given to driving the theoretical principles, time-sensitive software architectures and multimodal fusion and fission issues. And then presented the modeling of multimodal interaction and tools to allow rapid creation of multimodal interfaces.
(Lee, Armitage, Groves, & Stephens, 2009)	Systems for supporting group learning	- Entities (User, system) - Interaction architecture - Technology	This study is amongst the several publications in human computer interaction (HCI) that focus on using technologies as a tool to enhance experiences: in the same place but at a different time (for instance, using systems for supporting group learning such as notice boards, questions and answers, electronic debates and collaborative learning)
(Petrie & Bevan, 2009)	The evaluation of accessibility, usability and user experience	- Design principles and guidelines - Content - Structure - Evaluation	Research introduces a range of evaluation methods that assist developers in the creation of interactive electronic products, services and environments (eSystems) that are both easy and pleasant to use for the target audience. The
(Sung et al., 2010)	Designing an electronic guidebook for learning	- Entities (peer, computer, visitor, object) - Content composistion (background story, mission, hypothesis, evidence search, notebook)	This study proposed a human–computer–context interaction (HCCI) framework as a guide for designing a mobile electronic guidebook for a history museum

	engagement in a museum of history	- Architecture/Segment - Interaction - Technology	
(Ni, 2011)	A Framework of Freehand Gesture Interaction : Techniques , Guidelines , and Applications A Framework of Freehand Gesture Interaction : Techniques , Guidelines , And Applications	- user - input device, - Theories and Interaction Architecture Theories - interaction techniques, - fundamental design principles - Practical design guidelines.	The goal of the research is to construct a framework to support a systematic approach for designing freehand gesture-based interactions. Toward
(Martens & Antonenko, 2012)	Narrowing gender-based performance gaps in virtual environment navigation	- User - Spatial knowledge representation - Navigation	In order to utilize virtual environments to their fullest potential, users with different individual characteristics must be able to effectively navigate in these environments even though navigation or associated spatial tasks may not be the user's primary concern.
(Sandino, 2012)	A generic therapist Graphical User Interface design of the Virtual Reality Exposure Therapy system	- Entities (Therapist, system, user) - Multimodality (visual, audio, other) - Navigation - User control - Actions - Measurement	The researcher focused on the analysis and improvement of the therapist GUI in order to decrease the task load for the therapist.
(Angkananon et al., 2013b, 2013c)	Technology Enhanced	- People (role, ability/disability) - Objects (dimension, property, content)	The Technology Enhanced Interaction Framework supports developers and designers design and develop technology

	Interaction Framework	- Technology (Electronic, Non-electronic, User - Interface, Application or Service, Cost) - Interactions & Communication (People-People, People-Objects, People-Technology, People-Technology -People, People-Technology -Objects) - Time/Place (Location, Weather Condition, Signal Type and Quality, Background Noise, Lighting) - Interaction Layer (Culture, Intentionality, Knowledge, Action, Expression, Physical)	enhanced interactions involving people, technology and objects and has seven main components
(Y. Lu et al., 2014)	Promote physical activity among college students: Using media richness and interactivity in web design	- Navigability (browsing, elaboration, scaffolding, play, prominence, similarity) - Interactivity (interaction, activity, responsiveness, choice, control, tele-presence, flow, contingency, owness). - Agency (machine, bandwagon, authority, social presence, helper, identity) - Rich modality (realism, media, being there, distraction, bells and whistles, coolness, novelty, intrusiveness)	media richness and interactivity as design characteristics in 3d virtual environment are significant cues for users' attitude towards a multimedia technology.
(Shneiderman et al., 2016, 2009; Shneiderman & Plaisant, 1987)	Shneiderman's "Eight Golden Rules of Interface Design". Designing the user interface: strategies for effective human-computer interaction.	- Strive for consistency. - Enable frequent users to use shortcuts. - Offer informative feedback. - Design dialog to yield closure. - Offer simple error handling. - Permit easy reversal of actions. - Support internal locus of control. - Reduce short-term memory load.	Shneiderman's "Eight Golden Rules of Interface Design" for designing the user interface: strategies for effective human-computer interaction.
(Al-Aidaroos, 2017)	Conceptual model for usable	- Human entities - Technology	Proposed a conceptual model for usable multimodal mobile assistance during umrah called the personal digital mutawwif (PDM)

	multimodal mobile assistance during Umrah	- Structural component (opening, content, closing) - Content composition (interaction design, modalities, presentation, instruction modes, flow patterns) - Design principles (multimodal principles, information architecture, user interface layout) - Development approach (pre-production, production, and post production).	
(Lindner et al., 2017)	Design considerations and future directions for creating state of the art, next-generation Virtual Reality exposure therapies for anxiety disorders using consumer hardware platforms.	- Platform (stationary integrated or mobile) - Therapist-led or unguided self help (seen or unseen therapist) - User input - Interaction techniques - Domain knowledge - Gamification - User control - Stimuli intensity control or tailoring	The authors highlighted the current state of VR technology and discuss important therapeutic considerations in designing self-help and clinician-led VRETs, such as platform choice, exposure progression design, inhibitory learning strategies, stimuli tailoring, gamification, virtual social learning and more
(Apple_Developer, 2018b)	Human Interface Guidelines	- Aesthetic Integrity - Consistency - Direct Manipulation - Feedback - Metaphors - User Control	High expectations for quality and functionality for delivering extraordinary products that rises to the top of the App Store charts

Appendix E

Instrument for Expert Review: Multimodal Interaction Framework For Virtual Reality Foot Reflexology Stress Therapy (VR-FRST)

Dear Prof / Dr. / Sir / Mdm,

I am Prince-Hector C. Okere and currently pursuing a PhD program in Multimedia at Universiti Utara Malaysia (UUM). It is great pleasure to inform you that you have been selected to participate in this research on the reason as follows:

1. Your qualifications either in Human Computer Interaction (HCI) or Multimedia or Mobile Applications or Virtual Reality (VR) or Information Systems (IS) or Computer Science (CS) and/or related areas.
2. You have been teaching / researching in VR or Multimedia or HCI or instructional designs or IT and/or CS areas for at least five (5) years.

My research proposes A MULTIMODAL INTERACTION FRAMEWORK FOR VIRTUAL REALITY FOOT REFLEXOLOGY STRESS THERAPY. As part of this research, a multimodal interaction framework named VR-FRST has being designed. It is aimed at providing an alternative substitute for TFR application in relaxation, stress relief and complementary therapy.

One part of this research is to evaluate the proposed framework in a few dimensions as listed in the review form. You will see the review questions give you ample opportunity to use your expertise, experiences, interests, and creativity. It would be greatly appreciated if you could complete this evaluation form.

The information supplied will be treated as confidential and will be used for research purposes, which will be reported anonymously in academic publications.

Please feel free to contact me by email (okerejunior@yahoo.com) in regards to any queries or my supervisor Dr. Juliana Aida Abu Bakar (liana@uum.edu.my)

Thanking you for your time and assistance.

Instructions: Please read and go through the Document and Framework emailed to you carefully. Once this is done, with the expertise you possess, please provide feedback for all questions in the provided spaces.

Name

Gender	
Highest Education	
Level	
Occupation	
Affiliation	
Field of Expertise	
Years of Experience	

ITEMS TO REVIEW

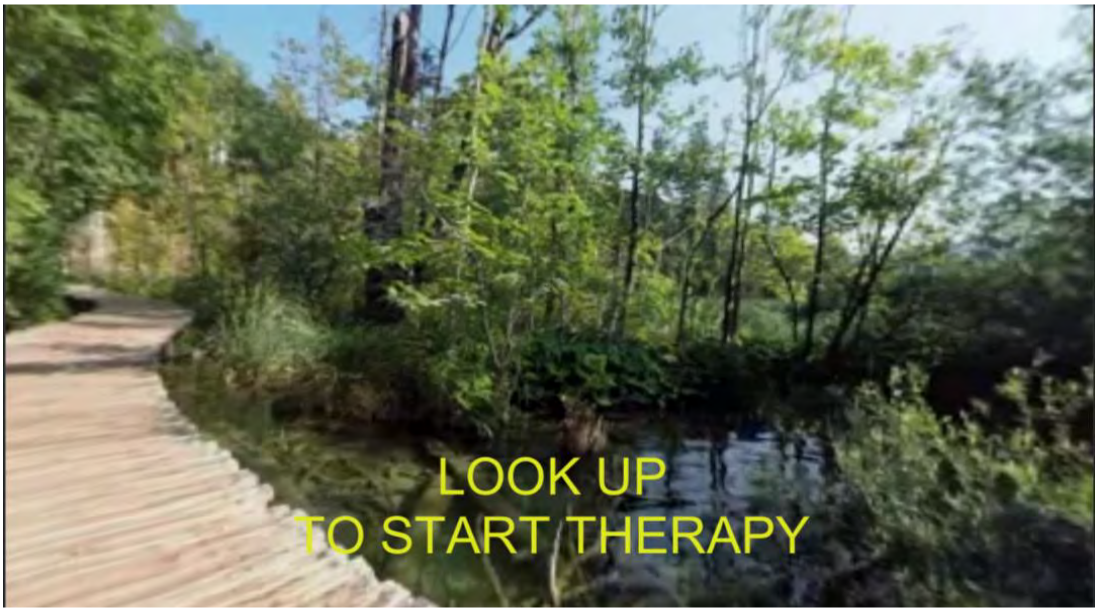
Based on the proposed Interaction Framework (as depicted in the given handout).	**Please select where you feel appropriate**		
1. The following Components in the proposed Interaction Framework are relevant. Technology Content Compositions Segment Composition Design Principles.	All are relevant	Some may be not relevant	Some are definitely not relevant / Please comment
2.The following design principles in the proposed Multimodal Interaction Framework for VR-FRST are understood. Multimedia Elements Design Principles Information Architecture Principles and Theories User Interface & Layout TFR User Requirements	It's easy to understand	Need some explanation	Needs very detail explanation / Please comment
3.The proposed elements in the design principles are understood Texts Graphic Animation Audio Video Organization Labelling Navigation System Transitions	It's easy to understand	Need some explanation	Needs very detail explanation / Please comment

4.The following terminologies in the entire interaction Framework are easy to understand.	It's easy to understand	Need some explanation	Needs very detail explanation / Please comment
Multimodal interaction			
Integrated Platform / Console			
Multimodal recognizers			
Multimodal Synthesizers			
Fussion			
Fission			
Labelling			

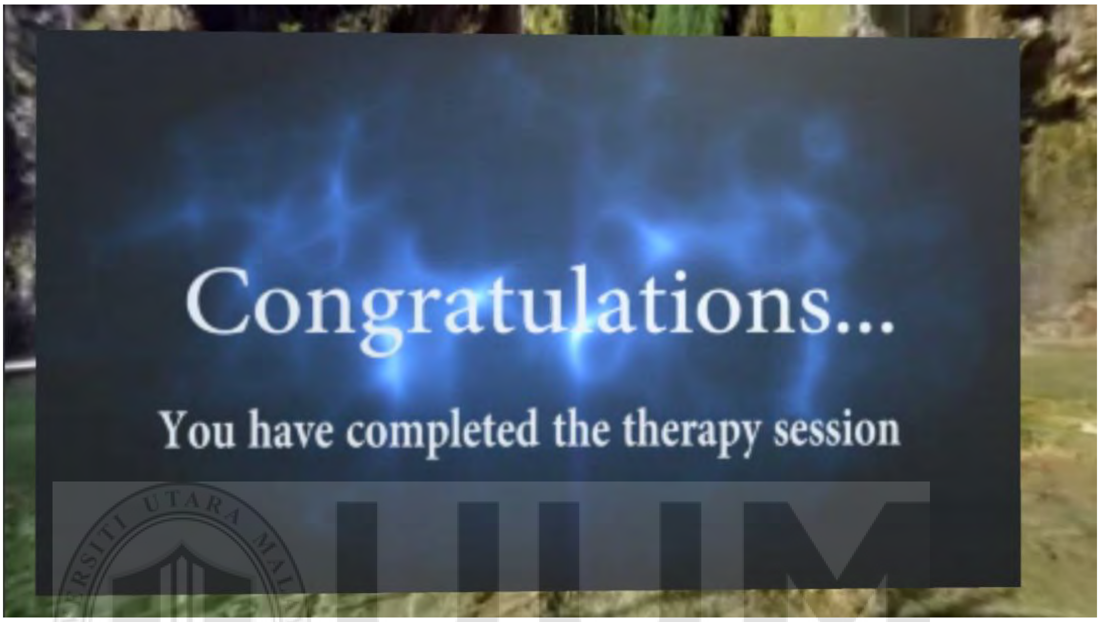
5. Please select (Yes / No) where you feel appropriate.	Yes	No /leave your comment
The connections and flows of all components are logical		
Overall, the multimodal interaction framework is readable		
6. Please leave any further comments		

Appendix F
VR-Foot-ReST Application Screenshots and Unity3D Game development Environment

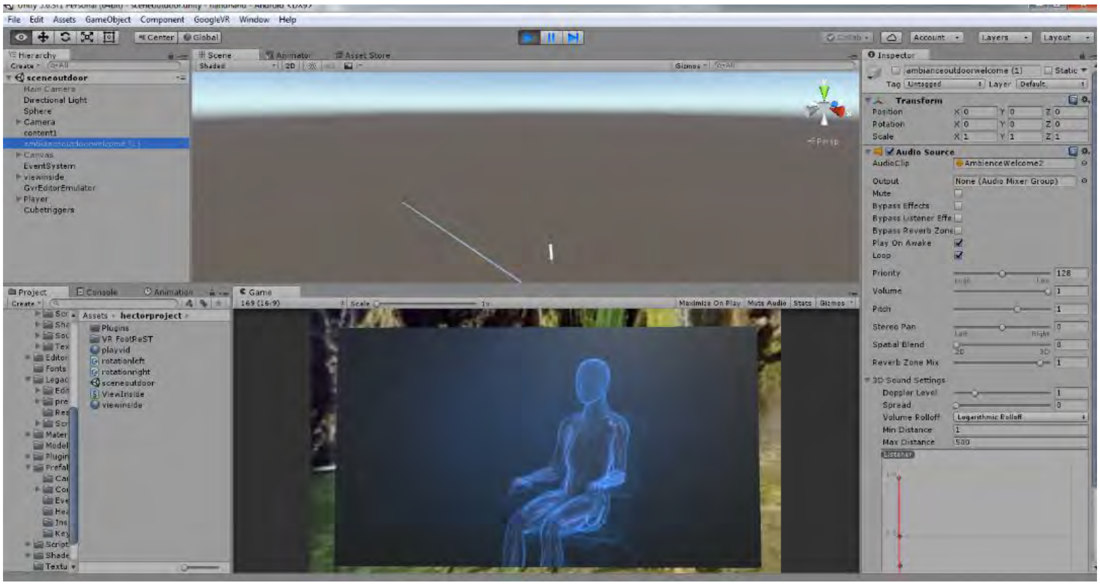
Waterfall Outdoor relaxing VR environment Front view



Waterfall Outdoor relaxing VR environment Rear view



After Therapy Congratulatory Message



Unity3D Game Development Environment

Appendix G

List of Publications

Okere, H. C., Bakar, J. A. A., & Mat, R. C. (2018a). Design Features of Virtual Reality Foot Reflexology Stress Therapy. Journal of Advanced Research in Dynamical and Control Systems, 10(Special Issue 10), 1472–1479. Retrieved from http://www.jardcs.org/backissues/abstract.php?archiveid=5049

Okere, H. C., Bakar, J. A. A., & Mat, R. C. (2018b). Virtual Reality and Its Potential for Stress Therapy. SMMTC Postgraduate Symposium 2018, 244. Retrieved from https://28536699-376730838878981982.preview.editmysite.com/uploads/2/8/5/3/28536699/proceedings_final_version.pdf#page=244

Okere, H. C., Bakar, J. A. A., & Mat, R. C. (2018c). Virtual Reality Foot Reflexology (VRST): A New Alternative in Foot Reflexology. International Journal of Engineering & Technology, 7(3.7), 383–387.